DIABETES IN AMERICA

Diabetes Data Compiled 1984

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service • National Institutes of Health

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National Diabetes Data Group

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U.S. DEPARTMENT OF HEALTH
AND HUMAN SERVICES
Public Health Service
National Institutes of Health
National Institute of Arthritis, Diabetes,
and Digestive and Kidney Diseases

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CONTENTS

Pages

Preface vii

Members of the National Diabetes Data Group ix

Chapter I. Summary .... I. 1-6

Chapter II. Classification and Diagnostic Criteria for Diabetes and Other Categories of Glucose Intolerance .... II. 1-10
Maureen I. Harris

Chapter III. Incidence and Risk Factors for Insulin-Dependent Diabetes .... III. 1-12
Ronald E. LaPorte and Karen J. Cruickshanks

Chapter IV. Incidence and Risk Factors for Noninsulin-Dependent Diabetes .... IV. 1-35
James Everhart, William C. Knowler, and Peter H. Bennett

Chapter V. Prevalence of Insulin-Dependent Diabetes .... V. 1-8
Ronald E. LaPorte and Naoko Tajima

Chapter VI. Prevalence of Noninsulin-Dependent Diabetes and Impaired Glucose Tolerance .... VI. 1-31
Maureen I. Harris

Chapter VII. Sociodemographic Characteristics of Adult Diabetics .... VII. 1-37
Thomas F. Drury, Kathleen M. Danchik, and Maureen I. Harris

Chapter VIII. Diabetes in Black Americans .... VIII. 1-24
Jeffrey M. Roseman

Chapter IX. Diabetes in Hispanic Americans .... IX. 1-11
Michael P. Stern

Chapter X. Diabetes in Asian Americans .... X. 1-12
Wilfred Y. Fujimoto

Chapter XI. Diabetes in North American Indians .... XI. 1-20
Maurice L. Sievers and Jeffrey R. Fisher

Chapter XII. Diabetic Ketoacidosis, Hyperosmolar Nonketotic Coma, Lactic Acidosis, and Hypoglycemia .... XII. 1-22
Howard A. Fishbein

CONTENTS (Continued)

Pages

Chapter XIII. Vision Disorders in Diabetes .... XIII. 1-36
Ronald Klein and Barbara E.K. Klein

Chapter XIV. Kidney Diseases Associated With Diabetes .... XIV. 1-31
William H. Herman and Steven M. Teutsch

Chapter XV. Peripheral Vascular Disease and Diabetes .... XV. 1-21
Pasquale J. Palumbo and L. Joseph Melton, III

Chapter XVI. Diabetes and Heart Disease .... XVI. 1-41
Elizabeth Barrett-Connor and Trevor Orchard

Chapter XVII. Diabetes and Hypertension .... XVII. 1-22
Michael J. Horan

Chapter XVIII. Cerebrovascular Disease and Diabetes .... XVIII. 1-18
Lewis H. Kuller, Janice S. Dorman, and Philip A. Wolf

Chapter XIX. Infections in Diabetics .... XIX. 1-18
Richard A. Kaslow

Chapter XX. Maternal Diabetes in Pregnancy .... XX. 1-17
John B. O'Sullivan, Maureen I. Harris, and James L. Mills

Chapter XXI. The Infant of the Diabetic Mother .... XXI. 1-19
James L. Mills and John B. O'Sullivan

Chapter XXII. Diabetes and Cancer .... XXII. 1-7
Marise S. Gottlieb

Chapter XXIII. Self-Assessed Health Status of Adult Diabetics .... XXIII. 1-12
Thomas F. Drury, Pennifer A. Erickson, and Anita L. Powell

Chapter XXIV. Therapy for Diabetes .... XXIV. 1-30
Donald B. Martin and Andrew R. Quint

Chapter XXV. Ambulatory Medical Care for Diabetes .... XXV. 1-13
Maureen I. Harris

Chapter XXVI. Hospital Utilization for Diabetes .... XXVI. 1-11
Pomeroy Sinnock

CONTENTS (Continued)

Pages

Chapter XXVII. Nursing Home Care for Diabetics .... XXVII. 1-13
Joan F. Van Nostrand

Chapter XXVIII. Disability Among Adult Diabetics .... XXVIII. 1-22
Thomas F. Drury

Chapter XXIX. Mortality From Diabetes .... XXIX. 1-48
Maureen I. Harris and Paul Entmacher

Chapter XXX. Mortality in Insulin-Dependent Diabetes .... XXX. 1-9
Janice S. Dorman and Ronald E. LaPorte

Chapter XXXI. Health Insurance and Health Care Coverage of Adult Diabetics .... XXXI. 1-14
Thomas F. Drury, Laura E. Montgomery, and Bruce B. Cohen

Chapter XXXII. Economic Impact of Diabetes .... XXXII. 1-13
Paul S. Entmacher, Pomeroy Sinnock, Emory Bostic, and Maureen I. Harris

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PREFACE

Diabetes in America has been sponsored by the National Diabetes Data Group (NDDG) of the National Institute of Arthritis, Diabetes, and Digestive and Kidney Diseases, National Institutes of Health. The NDDG is a congressionally authorized advisory body consisting of epidemiologists, clinicians, data system experts, and representatives of Federal and private agencies. It was established in 1977, in response to recommendations of the U.S. National Commission on Diabetes, to define diabetes data needs in scientific and public health issues, foster the collection and analysis of such data, make reliable information available to the lay, scientific, and medical communities, measure the medical and socioeconomic impact of diabetes, and promote standards in data collection and reporting.

The authors of Diabetes in America are well-recognized experts in their fields. Their participation was sought not only because of this specific scientific expertise, but also because they represent a spectrum of disciplines that reflect the broad interests of the diabetes community. This document represents, in the judgment of its authors and editors, a compilation and assessment of the most valid, accurate, and useful data on diabetes and its complications.

The need for such an assessment was identified by the National Commission on Diabetes in its report to Congress in 1976, and in 1977 "Diabetes Data Compiled" was published as an outgrowth of the report of the Committee on Scope and Impact of the Commission. Diabetes in America might also be considered a descendant of the "Diabetes Source Book" prepared in 1964 and revised in 1968 by the Diabetes and Arthritis Program of the U.S. Public Health Service.

The book has been designed to serve as a reliable resource for assessing the scope and impact of diabetes and its complications, determining health policy and priorities in diabetes, and identifying areas of need in research. The intended audience for Diabetes in America is heterogeneous and includes health policy makers at the Federal and local levels who need a sound quantitative base of knowledge to use in decision making; clinicians who need to know the probability that patients have diabetes and the prognosis of their disease; persons with diabetes and their families who need sound data on which to make decisions about their life with diabetes; and researchers who need to identify areas where scientific knowledge is lacking.

Four general areas are addressed: the demographic specificity of the disease in various segments of the population; the risk of developing diabetes and of developing its complications; the impact of diabetes on the patient and on the population in terms of morbidity, disability, mortality and cost; and its impact on resources of the health care system. Whenever possible, the classification system and diagnostic criteria recommended by the National Diabetes Data Group in 1979 have been used.

We have tried to exploit all extant data sources, both published and unpublished. In this regard, much credit goes to our diabetes research colleagues who provided unpublished data or who reanalyzed previously published results; to the Diabetes Control Activities in various States sponsored by the Centers for Disease Control who developed new sources of population-based diabetes data; and to many analysts in the National Center for Health Statistics who tabulated diabetes-specific data from their national surveys.

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CHAPTER I. SUMMARY

EPIDEMIOLOGY

Diabetes mellitus comprises a heterogeneous group of disorders characterized by high blood glucose levels. Approximately 5.8 million people in the United States have been diagnosed by a physician as being diabetic, and an additional 4 to 5 million people have diabetes but have not yet been diagnosed. There are four main types of diabetes. Insulin-dependent diabetes mellitus (IDDM) constitutes about 5-10 percent of all cases of diabetes, and most of the remainder is noninsulin-dependent diabetes mellitus (NIDDM). About 2 percent of diabetes is the type that is secondary to or associated with other conditions. Gestational diabetes, a transient condition during pregnancy, occurs in about 2 to 5 percent of pregnancies.

Diagnosis of diabetes is made either by the presence of the classical symptoms of diabetes together with elevated blood glucose levels, by elevated fasting glucose levels, or by an abnormal oral glucose tolerance test.

Approximately 500,000 persons are diagnosed as diabetic each year. The annual incidence of IDDM is about 12-14 new cases per 100,000 children ages 0-16 years, and by age 20 about 0.3 percent of persons have developed IDDM. About half of persons with IDDM are currently older than age 20 years. The annual incidence of NIDDM is about 320 per 100,000 persons ages 20 years and older. About 2.35 percent of the population has been diagnosed as having NIDDM, and at ages 65 years and older virtually 8.6 percent have NIDDM.

The incidence (new cases) of IDDM appears to not have increased in the United States during the period in which it has been studied (1965-80). However, during the 1960's, there was a rise in the incidence of total diabetes, possibly due to active screening for NIDDM. From a peak incidence of 300 per 100,000 population in 1973, the rate declined to 230 per 100,000 in 1979-81. Prevalence has continued to rise, however, as a result of a 19 percent decline since 1970 in the diabetes underlying cause mortality rate.

In 1982, 34,583 deaths were attributed to diabetes as the underlying cause of death, resulting in diabetes being ranked as the seventh leading underlying cause of death. In

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The data in this chapter are drawn from the other chapters of Diabetes in America.

approximately 95,000 additional deaths, diabetes was listed as a contributing cause of death. The majority of death certificates (about 75 percent) listing diabetes also list a cardiovascular condition. Ischemic heart diseases are involved in about 60 percent of diabetes deaths, and cerebrovascular diseases in about 25 percent. About 76 percent of recorded deaths of diabetics occur at ages 65 years and older. Survival for 25 years after diagnosis of NIDDM may be about 70-80 percent of expected survival in the general adult population.

Mortality among IDDM patients is about 3 per 1,000 diabetics per year at ages below 25 years and about 20/1,000/year at ages 25 years and older. Rates for white males and females with IDDM are 5 and 11 times greater than for nondiabetics, and rates for blacks with IDDM are about twice those for whites. About 12 percent of persons with IDDM die within 20 years after onset of diabetes. The primary cause of death below age 20 years is acute diabetic complications, but at older ages renal disease accounts for nearly half of deaths. Renal disease deaths among IDDMs are about 500 times higher than in the general population at these young ages, and cardiovascular disease deaths are about 13 times higher.

Diabetics are older than the general population of the United States. Among persons aged 20 years and older, the median age of the general population (42 years) is 19 years lower than the median age of diabetics (61 years). Within age groups, however, diabetics are very similar to the general population with regard to a number of demographic factors. These include percent with European and Hispanic origin, region and location of residence, marital status, living arrangements, employer and industry of employed persons, and veteran status (men). However, a higher proportion of diabetics are blacks than in the general population. Diabetics also have less years of schooling, are less likely to be in the labor force and to be employed, and have lower family incomes than the general adult population.

Among adult diabetics, about half of men and one-fourth of women are actively involved in the work-force, with substantially higher employment rates among young diabetics (83 percent of men and 55 percent of women) and lower rates among diabetics ages 65 years and older (17 and 6 percent). About half are employed in white-collar jobs. Two-thirds of adult diabetics live in urban areas, about half have completed high school or have more years of schooling, about two-thirds are married and live with their spouse (although 80 percent of diabetic men but only 54 percent of diabetic women are married). About 42 percent had an annual family income of $15,000 or greater in 1981.

Genetic, environmental, and lifestyle factors place an individual at increased risk for developing diabetes. About 6 percent of adults with NIDDM are of Hispanic origin and 15 percent are black. Rates of NIDDM in these groups, as well as in Asian Americans, appear to be higher than in whites. Although some American Indian tribes have rates of diagnosed diabetes that are among the highest recorded in the world, this group of Americans constitute a small fraction of the diabetic population. Above age 25 years, the incidence of diabetes estimated from interview surveys is about 20 percent higher in females than in males, although the total prevalence of diabetes (diagnosed and undiagnosed) is about the same for the two sexes. The most important risk factors for NIDDM are increasing age, higher blood glucose concentration, family history of diabetes, and obesity. Rates of NIDDM in the United States tend to be greater in persons with urban versus rural habitation and lower versus higher socioeconomic status.

The incidence of IDDM is similar in males and females and is 1.5 times higher in whites than blacks, although incidence rates vary widely internationally. The risk of IDDM in siblings of IDDM patients is 7 to 18 times that of the risk in the general population, although only about one in 50 siblings of IDDMs develops IDDM before age 20 years. The human leucocyte antigen (HLA) system seems to be related to onset of IDDM, as individuals with certain HLA types, particularly DR3 and DR4, are at increased risk for development of IDDM. Advanced maternal age and the presence of islet cell antibodies may also be risk factors.

COMPLICATIONS OF DIABETES

Acidosis and Coma

Approximately 3 to 8 episodes of diabetic ketoacidosis (DKA) occur annually per 1,000 diabetics. Infections and noncompliance with diet and medication appear to precipitate at least 50 percent of these episodes, and DKA accompanies the onset of diabetes in about 20-30 percent of new cases of diabetes. Two to 14 percent of all hospitalizations for diabetes involve acidosis/coma. DKA is the underlying cause of about 10 percent of diabetes deaths recorded on death certificates each year and causes death in about 57 per 100,000 diabetics annually.

Vision

Diabetes, particularly diabetic retinopathy, is the leading cause of new cases of blindness in people aged 20-74 years in the United States. Approximately 5,800 diabetics become blind each year. About 40,000 diabetics are blind, 22 percent report some visual impairment, and 5 percent report severe visual impairment. Twelve percent report having cataracts and 11 percent report glaucoma, which are 2-3 times the rates reported by the general population. Panretinal photocoagulation can reduce the incidence of blindness in persons with severe proliferative retinopathy by about 50 percent.

Kidney Diseases

Approximately 10 percent of diabetics have diabetic nephropathy as marked by the presence of constant proteinuria. Its prevalence increases with duration of diabetes, and after 15 years of diabetes about one-third of persons with IDDM and one-fifth with NIDDM have developed nephropathy. The annual incidence of diabetic end-stage renal disease (ESRD) is 18 per million population, which accounts for one-fourth of all new cases of ESRD. ESRD is about 15 times more common in IDDMs than in NIDDMs, and 3 times more common in black than in white diabetics. Hypertension and glucose control are associated with a higher prevalence of nephropathy. One-year survival of diabetic patients treated with dialysis and transplantation is about 75 and 82 percent, respectively.

Peripheral Vascular Disease

Diminished arterial perfusion to the legs and feet (arteriosclerosis obliterans, ASO) is present in 8 percent of adult diabetics at diagnosis and, by 20 years duration of diabetes, 45 percent have ASO. The incidence in diabetic men and women is 4 to 7 times greater than in their nondiabetic counterparts. About 15 percent of diabetics have experienced ulcer on the feet or ankles. The incidence of gangrene is 4.5 cases per 1,000 diabetics per year, and survival of diabetics with gangrene is only about 45 percent of expected. Diabetes accounts for 40-45 percent of all nontraumatic amputations and an amputation occurs in about 60 per 10,000 diabetics annually. Survival for 3 years after an amputation is only about 50 percent of expected.

Heart Diseases

Approximately twice as many diabetics as nondiabetics have a medical history of a heart condition, clinically manifest heart disease, or abnormalities on resting and exercise electrocardiograms. The risk is even higher for diabetic women compared to nondiabetic women. Coronary heart disease is present in about 13 percent of adult diabetics and congestive heart failure in about 7 percent. Rates increase with age, but duration of diabetes and glucose control are not clearly related to the risk of heart disease. Ischemic heart disease is involved in about 50-60 percent of recorded deaths in adult diabetics and in about 15 percent of young diabetics. The risk of death from ischemic heart disease in diabetics is about twice that in nondiabetics.

Hypertension

About half of diabetics have a medical history of hypertension. The rate of hypertension in diabetics is 2-3 times that of nondiabetics at ages 20-44 years and 1.5 times higher at ages 65 years and older. Rates seem to be higher in female than in male diabetics, and in black than in white diabetics. In only about 30-50 percent is blood pressure controlled. Rates increase with age, but duration of diabetes and degree of glucose control do not seem to be risk factors for hypertension in diabetics. Increased blood pressure is a major risk factor for development of retinopathy, nephropathy, cerebrovascular disease, and heart disease. Hypertension is implicated in 4.4 percent of deaths recorded with diabetes as the underlying cause, and diabetes is involved in 10 percent of deaths recorded as due to hypertension.

Cerebrovascular Disease

The occurrence of stroke in diabetics is about 2 to 6 times greater than in nondiabetics. At ages 65-84 years, stroke occurs annually in 100-175 per 10,000 diabetics. Diabetes is implicated in 7 percent of deaths recorded as due to stroke, and cerebrovascular diseases are present in about 25 percent of recorded deaths due to diabetes. Survival of diabetics after a stroke is poor and only about 20 percent are alive 5 years later.

Infections

Kidney and urinary tract infections may occur at relatively higher rates in diabetics than in nondiabetics, but most infections appear to be no more common in diabetics. Infections account for about 15 percent of hospital admissions of young diabetics, and mortality due to infections is reported to be the cause of about 1 percent of deaths of diabetics.

Pregnancy

Approximately 4 to 15 per 1,000 pregnancies occur in diabetic women, the majority of which are probably in insulin-dependent diabetics. Gestational diabetes occurs in about 25 to 50 per 1,000 pregnancies, and advanced maternal age appears to be the most reliable correlate of abnormal glucose tolerance in pregnancy. Risk factors for subsequent development of diabetes include gestational diabetes and birth of a heavy baby, but obesity, age, and family history of diabetes are also risk factors. Maternal mortality in diabetic pregnancies appears to be no different from the low rate in pregnancies of nondiabetic women.

Infants of Diabetic Mothers

Perinatal mortality occurs in 4 to 8 percent of diabetic pregnancies, a rate which is 2 to 4 times higher than in nondiabetic pregnancies, although at tertiary care centers this risk may be lower. About 5 to 10 percent of infants of diabetic mothers have congenital anomalies at birth, about one-third of which are fatal. Macrosomia is about twice as frequent in offspring of diabetic women, and infants of diabetic mothers may also be at higher risk for low blood glucose and calcium levels, respiratory distress, and jaundice.

Cancer

The incidence of both cancer and diabetes have been increasing for at least 30 years, but there appears to be no excess deaths due to cancer among diabetics. About 1 percent of recorded deaths of diabetics also list cancer of the pancreas, and about 2.7 percent of deaths due to cancer list diabetes.

Neuropathy

This topic was not included in Diabetes in America because of a lack of reliable data on the occurrence of neuropathy in populations with diabetes.

HEALTH STATUS AND DISABILITY

About half of adult diabetics assess their health as fair or poor, while only about 16 percent of the general adult population describe their health in these unfavorable terms. At the favorable end of the health status spectrum, about 14 percent of adult diabetics assess their health as excellent, while 44 percent of the general population rate their health that favorably.

Adult diabetics experience about 64 restricted activity days, 24 bed days, and 12 work-loss days per person per year; about one-third of these days are attributed by diabetics to their diabetes. The numbers of days in the general population are 2 to 3 times lower. The frequency of disability in adult diabetics is 2 to 3 times that in the general population, whether disability is measured by limitation in usual activity (working, keeping house, etc.), limitation in mobility, presence of physical impairments, needing help in personal care activities, functional capacity limitation (walking, standing, kneeling, etc.), or participation in public disability programs. However, when diabetics are compared to nondiabetics with other chronic medical conditions (e.g., cataracts, glaucoma, arteriosclerosis, hypertension, heart conditions, stroke), these differentials are reduced considerably or even reversed. Higher rates of disability occur in diabetics living outside metropolitan areas, with less education, and with lower family income.

Diabetics are more likely to be work-disabled, and to be severely so. Half of diabetics ages 20-64 years are limited in the kind or amount of work they can do. One-third are unable to work regularly or at all, compared to only 15 percent of the general population ages 20-64 years.

HEALTH CARE

By definition, all persons with IDDM use insulin. About 25 percent of NIDDMs use insulin, 35 percent use oral agents, and 15 percent use a diet alone for control of their diabetes. About 25 percent of diabetics are not on any of these three therapies.

Half of adult diabetics have seen a physician for their diabetes in an ambulatory setting within the previous 2 to 6 months, but about 10 percent report that they have not seen a physician in over a year. The average number of visits to physicians for diabetes is about 3 per diabetic per year, although diabetics may see a physician as many as 6-11 times per year. Forty-eight percent of ambulatory physician visits for diabetes are to general and family practitioners, and 33 percent to internists. About 30 percent of diabetics go to dentists at least once per year, and about 50 percent have had their eyes examined within the past two years.

The rate of hospitalization for diabetes at ages 64 years and younger is about 33 per 10,000 diabetics annually; for ages 65 years and older, the rate is about 50 per 10,000. A large proportion of these hospitalizations are for diabetic control. The rate of hospitalization is 2.4 times greater for adult diabetics than for nondiabetics, and for children the rate is 5.3 times greater.

Approximately 190,000 diabetics are in nursing homes, comprising 15 percent of the nursing home population. About 75 percent are ages 75 years and older, and 75 percent are female. The characteristics of these diabetics are similar to nondiabetic residents, except that the health of diabetics is somewhat poorer.

ECONOMIC ASPECTS OF DIABETES

About 90 percent of adult diabetics, and virtually every diabetic age 65 years and older, have at least one form of health care coverage or health insurance. Government programs are major sources, with 41 percent of adult diabetics being covered under Medicare (96 percent of diabetics ages 65 years and older), 11 percent under Medicaid, and 12 percent under military and Veterans Administration health benefits. Private health insurance is held by 71 percent of diabetics, compared to 79 percent of the general adult population.

Because diabetes is related to other acute and chronic conditions that are often considered the reason for medical expenses incurred by diabetics, it is difficult to estimate the full economic impact of diabetes. However, the lowest estimates of costs directly attributable to diabetes are $13.8 billion annually, which represents 3.6 percent of total United States health costs. This is composed of $7.4 billion due to medical care expenses specifically for diabetes (about half due to hospitalizations and one-fourth to nursing home care); and $6.3 billion due to indirect costs attributable to disability and premature death among diabetics. Estimates of all costs incurred by diabetics for medical care are about twice as high as the above costs that are directly attributed to diabetes.

CHAPTER II. CLASSIFICATION AND DIAGNOSTIC CRITERIA FOR DIABETES AND OTHER CATEGORIES OF GLUCOSE INTOLERANCE

Maureen I. Harris, Ph.D., M.P.H.

SUMMARY

Diabetes mellitus comprises a heterogeneous group of disorders characterized by high blood glucose levels. Four major types of diabetes have been defined by the National Diabetes Data Group: insulin-dependent diabetes (IDDM), noninsulin-dependent diabetes (NIDDM), gestational diabetes (GDM), and diabetes secondary to other conditions. In addition, impaired glucose tolerance (IGT) is a class that encompasses persons whose glucose tolerance is intermediate between normal and diabetic. Diabetes can be diagnosed by the presence of classical signs and symptoms of diabetes and unequivocally elevated blood glucose levels; by a fasting plasma glucose greater than or equal to 140 mg/dl; or by an abnormal oral glucose tolerance test, with a venous plasma glucose value greater than or equal to 200 mg/dl at 2 hours after 75 grams oral glucose being a hallmark criterion for diabetes.

CLASSIFICATION OF THE TYPES OF DIABETES

Diabetes mellitus is a clinically and genetically heterogeneous group of disorders that have one common feature—abnormally high levels of glucose in the blood due to either insulin deficiency or impaired effectiveness of insulin. It has been centuries since this syndrome was first recorded; however, over the past several decades, medical research has led to the recognition that the different types of diabetes may have different causes, although their pathologic courses may be similar. The classification of this heterogeneous group of disorders based on this recent knowledge is summarized in Table 1. This classification has been recommended by the National Diabetes Data Group of the National Institutes of Health (NDDG 1979) and by the Expert Committee on Diabetes of the World Health Organization (WHO 1980). It includes the types of diabetes seen in the United States, but does not include diabetic syndromes common in some countries but rarely seen in the United States, such as J-type diabetes and malnutrition-associated diabetes. The table highlights the different clinical presentations and genetic and environmental etiologic factors that permit discrimination among the types of diabetes.

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TABLE 1. *Classification of the types of diabetes*

Class Name	Former Terminology	Characteristics
Insulin-dependent diabetes mellitus (IDDM, Type I)	Juvenile diabetes Juvenile-onset diabetes (JOD) Ketosis-prone diabetes Brittle diabetes	Low or absent levels of circulating endogenous insulin and dependent on injected insulin to prevent ketosis and sustain life Onset predominantly in youth but can occur at any age Associated with HLA D3 and D4 Abnormal immune response and islet cell antibodies are frequently present at diagnosis Etiology probably only partially genetic, as only 35% of monozygotic twins are concordant
Noninsulin-dependent diabetes mellitus (NIDDM, Type II) Subtype obese Subtype nonobese	Adult-onset diabetes Maturity-onset diabetes (MOD) Ketosis-resistant diabetes Stable diabetes	Insulin levels may be normal, elevated, or depressed Not insulin-dependent or ketosis-prone under normal circumstances, but may use insulin for treatment of hyperglycemia or during stress conditions Onset predominantly after age 40, but can occur at any age Approximately 60 percent of patients are obese Hyperinsulinemia and insulin resistance characterize some patients Etiology probably strongly genetic as almost 100% of monozygotic twins are concordant
Gestational diabetes (GDM)	Gestational diabetes	Glucose intolerance that has its onset during pregnancy; virtually all patients return to normal glucose tolerance following parturition Conveys increased risk for progression to diabetes Associated with increased risk of congenital malformations
Other types of diabetes, including or secondary to those associated with: Pancreatic disease Hormonal disease Drugs or chemical exposure Insulin receptor abnormalities Certain genetic syndromes	Secondary diabetes	In addition to the presence of the specific condition, hyperglycemia at a level diagnostic of diabetes is also present Causes of hyperglycemia are known for some cases, e.g., pancreatic disease; in other cases an etiologic relationship is suspected (See Table 2 for further list of conditions with which hyperglycemia is associated.)

SOURCE: National Diabetes Data Group. Classification and diagnosis of diabetes and other categories of glucose intolerance. Diabetes 28:1039-57, 1979.

There are about 5.8 million diagnosed cases of diabetes in the United States, based on 1984 estimates of the population. NIDDM is by far the most prevalent type, comprising about 90-95 percent of all diagnosed cases of diabetes; IDDM constitutes about 5-10 percent (Hadden and Harris 1985). GDM occurs in approximately 2-5 percent of all pregnancies, or in about 70,000 to 180,000 women each year, with about 98 percent of these cases returning to normal glucose tolerance after parturition

(Merkatz et al. 1980). An estimate of the prevalence of diabetes associated with or secondary to other conditions indicates that this type occurs in perhaps 2 percent of all disorders comprising the syndrome of diabetes (Melton et al. 1983). In addition to these diagnosed cases, there are about 4-5 million undiagnosed cases of NIDDM in the United States (Harris 1982). Numerous terms are no longer considered scientifically accurate or socially appropriate to describe persons with diabetes. Some of these are shown under "former terminology" in Table 1.

The heterogeneity within the syndrome of diabetes implied in Table 1 has important implications for research and for clinical management of patients. For example, it is likely that different genetic and environmental etiologic factors result in similar diabetic phenotypes (hyperglycemia and classic diabetic complications), although the disorders in Table 1 may differ markedly in pathogenesis, natural history, and responses to therapy and preventive measures. It is possible, although not proven, that GDM arises from the physiological stresses of pregnancy, and that diabetes associated with other conditions is strictly secondary to these other conditions. Some of the numerous conditions known to be associated with a level of hyperglycemia characteristic of diabetes are shown in Table 2. The causes of IDDM and NIDDM, the subject of intensive research over many decades, remain unknown, although both can be accompanied by ketoacidosis, blindness, kidney failure, premature cardiovascular disease, stroke, amputations, and other complications. Each class in Table 1 is probably still heterogeneous in etiology and pathogenesis, and further research is needed to define more precisely the different types of diabetes in order to elucidate their etiologies and devise appropriate preventive and therapeutic strategies.

DIAGNOSTIC CRITERIA FOR DIABETES

It is widely believed that the pathologic consequences of diabetes are due to high glucose levels that the body experiences when metabolism of glucose is deranged. This contention has never been proven. Nevertheless, a number of prospective observational studies (Al Sayegh and Jarrett 1979, Bennett et al. 1976, Fitzgerald and Malins 1976, Keen et al. 1982, O'Sullivan and Mahan 1968) have led to the conclusion that diabetic complications (e.g., retinopathy, nephropathy, fetal mortality) are more likely to occur when blood glucose levels exceed certain values over extended periods of time. Consequently, the criteria for diagnosis of diabetes recommended by NDDG and WHO are based on plasma glucose levels believed to be predictive of the characteristic complications of diabetes. Earlier diagnostic criteria that employed urine glucose or casual and postprandial glucose values are no longer considered by NDDG or WHO to be adequate for the diagnosis of diabetes.

TABLE 2. *Conditions and syndromes associated with diabetes mellitus and impaired glucose tolerance*

1. Pancreatic Disease
   - Transient diabetes of the newborn
   - Functional immaturity of insulin secretion
   - Acquired--traumatic, infections, toxic, neoplastic
2. Hormonal
   - a. Hypoinsulinemic
     - Pheochromocytoma
     - Somatostatinoma
     - Aldosteronoma
     - Hypoparathyroidism--hypocalcemia
     - Type-I isolated growth hormone deficiency
     - Multitropic pituitary deficiency
     - Hypothalamic lesions--"piqure" diabetes (of Claude Bernard)
   - b. Hyperinsulinemic
     - Glucocorticoids
     - Progestins and estrogens
     - Growth hormone--acromegaly
     - Glucagon
     - Type-II isolated growth hormone deficiency
3. Drugs and Chemical Agents
   - a. Diuretics and Antihypertensive Agents
     - Chlorthalidone (Hygroton, Combipres, Regroton)
     - Clonidine (Catapres, Combipres)
     - Diazoxide (Hyperstat, Proglycem)
     - Furosemide (Lasix)
     - Metalazone
     - Thiazides
     - Bumetamide
     - Clopamide
     - Clorexolone
     - Ethacrynic acid (Edecrin)
   - (Note: hyperglycemic response to diuretics may be independent of K^+ fluctuations)
   - b. Hormonally Active Agents
     - Adrenocorticotropin (Acthar)
     - Glucagon
     - Glucocorticoids
     - Oral contraceptives
     - Somatotropin
     - Thyroid hormones (thyrotoxic doses)
       - Dextrothyroxine (Choloxin)
     - Calcitonin (Calcimar)
     - Medroxyprogesterone (AMEN, Depo-Provera, Provera)
     - Prolactin

Drugs and Chemical Agents (continued)

- c. Psychoactive Agents
  - Chlorprothixene (Teractan)
  - Haloperidol (Haldol)
  - Lithium carbonate (Eskalith, Lithane)
  - Phenothiazines
    - Chlorpromazine (Thorazine)
    - Perphenazine (Trilafon, Etrafon, Triavil)
  - Clopenthixol
  - Tricyclic Antidepressants
    - Amitriptyline (Elavil, Endep, Etrafon, Triavil)
    - Desipramine (Norpramin, Pertofrane)
    - Doxepin (Adapin, Sinequan)
    - Imipramine (Presamine, Tofranil, Imavate)
    - Nortriptyline (Aventyl)
  - Marijuana
- d. Catecholamines and Other Neurologically Active Agents
  - Diphenylhydantoin (Dilantin)
  - Epinephrine
  - Isoproterenol
  - Levodopa
  - Norepinephrine
  - Buphenine (Nylidrin)
  - Fenoterol
  - Propranolol (Inderal)
- e. Analgesic, Antipyretic, and Anti-inflammatory Agents
  - Indomethacin (Indocin)
  - Acetaminophen (overdose amounts)
  - Aspirin (overdose amounts)
  - Morphine
- f. Antineoplastic Agents
  - Alloxan
  - L-asparaginase
  - Streptozotocin
  - Cyclophosphamide (Cytoxan)
  - Megestrol Acetate (Megace)
- g. Miscellaneous
  - Isoniazid (INAH, Nydrazid, others)
  - Nicotinic acid
  - Carbon disulfide
  - Cimetidine
  - Edetic acid (EDTA)
  - Ethanol
  - Heparin
  - Mannoheptulose
  - Nalidixic acid (NegGram)
  - Nickel chloride
  - Niridazole
  - Pentamidine (Lomidine)
  - Phenolphthalein (Ex-Lax)
  - Rodenticide (Vacor)
  - Thiabendazole

(Continued)

TABLE 2. (Continued)

4. Insulin receptor abnormalities
   - Defect in insulin receptor
   - Congenital lipodystrophy associated with virilization, acanthosis nigricans
   - Antibody to insulin receptor-associated immune disorders
5. Genetic Syndromes
   - a. Inborn Errors of Metabolism
     - Glycogen-storage disease types I and III
     - Acute intermittent porphyria
     - Hyperlipidemias
     - Fanconi syndrome--hypophosphatemia
     - Thiamine responsive megaloblastic anemia
   - b. Insulin-Resistant Syndromes
     - Ataxia telangiectasia
     - Myotonic dystrophy
     - Mendenhall's syndrome
     - Lipoatrophic syndromes
     - Leprechaunism
     - Acanthosis nigricans and insulin resistance
   - c. Hereditary Neuromuscular Disorders
     - Optic atrophy--diabetes mellitus
     - Diabetes insipidus, nerve deafness
     - Muscular dystrophies
     - Late onset proximal myopathy
     - Huntington's chorea
     - Machado's disease
     - Herrman syndrome
     - Friedreich's ataxia
     - Alstrom syndrome
     - Edward's syndrome
     - Pseudo-Refsum's syndrome
   - d. Progeroid Syndromes
     - Cockayne syndrome
     - Werner syndrome
     - Progeria

Genetic Syndromes (continued)

   - e. Syndromes with Glucose Intolerance Secondary to Obesity
     - Prader-Willi syndrome
     - Achondroplastic dwarfism
   - f. Cytogenetic Disorders
     - Down
     - Turner
     - Klinefelter
   - g. Pancreatic Degeneration
     - Congenital absence of the pancreas
     - Congenital absence of the islets
     - Relapsing pancreatitis
     - Cystic fibrosis
     - Schmidt syndrome
     - Hemochromatosis
     - Thalassemia
     - Anti-trypsin deficiency
     - Coeliac disease
   - h. Endocrine Disorders
     - Growth hormone deficiency
     - Panhypopituitary dwarfism
     - Laron dwarfism
     - Pheochromocytoma
     - Familial hyperglucagonemia
     - Somatostatinoma with neurofibromatoses
   - i. Miscellaneous
     - Steroid-induced ocular hypertension
     - Epiphyseal dysplasia and infantile-onset diabetes
6. Other Types
   - Diabetes associated with malnourished populations

SOURCE: National Diabetes Data Group. Classification and diagnosis of diabetes and other categories of glucose intolerance. Diabetes 23:1039-57, 1979; and Rotter, JI, and D Rimoin, personal communication, 1984.

The NDDG and WHO criteria for diabetes (Table 3) are virtually identical, but there are some differences. Both permit a diagnosis based on the presence of the classic diabetic symptoms and random plasma glucose values of 200 mg/dl or greater; both also permit a diagnosis of diabetes based on a fasting plasma glucose concentration of 140 mg/dl or greater (7.8 mmol/L). In persons without unequivocal symptoms and in those with lower random or fasting plasma glucose levels, both require a glucose tolerance test in which blood glucose concentration is measured 2 hours after a 75-gram oral glucose challenge. The NDDG and WHO both require that, for diagnosis of diabetes, this 2-hour value be equal to or greater than 200 mg/dl; the NDDG also requires that a midtest blood sample be taken after ingesting the 75-gram glucose challenge and that the glucose concentration of this sample also be greater than or equal to 200 mg/dl. This requirement for a midtest value by NDDG makes only a slight difference; 91 percent of persons in a sample survey of the United States population whose 2-hour value exceeded 200 mg/dl also had 1-hour values exceeding 200 mg/dl (Hadden et al. 1985).

TABLE 3. *Criteria for diagnosis of diabetes in nonpregnant adults: Recommendations of the National Diabetes Data Group (NDDG) and the World Health Organization (WHO)*

I. In a Clinical Setting

Any one of the following is considered diagnostic of diabetes. In each case, measurement of glucose concentration should be repeated on a second occasion to confirm the diagnosis.

A. Presence of the classic symptoms of diabetes, such as polyuria, polydipsia, ketonuria, and rapid weight loss, together with gross and unequivocal elevation of plasma glucose, e.g., postprandial or random plasma glucose concentration > 200 mg/dl (11.1 mmol/L).

B. Elevated fasting glucose concentration on more than one occasion:

venous plasma $\geq$ 140 mg/dl (7.8 mmol/L)
venous whole blood $\geq$ 120 mg/dl (6.7 mmol/L)
capillary whole blood $\geq$ 120 mg/dl (6.7 mmol/L)

If the fasting glucose concentration meets these criteria, the OGTT is not required. Indeed, virtually all persons with FPG $\geq$ 140 mg/dl will exhibit an OGTT that meets or exceeds the criteria in I.C. below.

C. Fasting glucose concentration less than that which is diagnostic of diabetes (I.B., above), but sustained elevated glucose concentration during the OGTT. The NDDG requires that both the 2-hour sample and some other sample taken between administration of the 75-gram glucose dose and 2 hours later meet the following criteria; the WHO requires only that the 2-hour sample meet these criteria:

venous plasma $\geq$ 200 mg/dl (11.1 mmol/L)
venous whole blood $\geq$ 180 mg/dl (10.0 mmol/L)
capillary whole blood $\geq$ 200 mg/dl (11.1 mmol/L)

II. In an Epidemiologic Setting

In epidemiologic research or during screening for diabetes, it will generally be impossible to conduct the careful plasma glucose measurements above. Any one of the following criteria, which are compromises, is considered diagnostic of diabetes in these circumstances:

A. Medical history of diabetes diagnosed by a physician

B. A single fasting glucose concentration:

venous plasma $\geq$ 140 mg/dl (7.8 mmol/L)
venous whole blood $\geq$ 120 mg/dl (6.7 mmol/L)
capillary whole blood $\geq$ 120 mg/dl (6.7 mmol/L)

C. A single glucose concentration 2 hours after ingesting a 75-gram glucose dose:

venous plasma $\geq$ 200 mg/dl (11.1 mmol/L)
venous whole blood $\geq$ 180 mg/dl (10.0 mmol/L)
capillary whole blood $\geq$ 200 mg/dl (11.1 mmol/L)

TABLE REFERENCES

a. National Diabetes Data Group. Classification and diagnosis of diabetes and other categories of glucose intolerance. Diabetes 28:1039-57, 1979.
b. World Health Organization, Expert Committee on Diabetes. Technical Report Series No. 646, Geneva, Switzerland, 1980.

In patients for whom inadequate information is obtained it may be difficult to distinguish among IDDM, NIDDM, and diabetes secondary to other diseases. For IDDM there may be evidence of insulinopenia either by direct measurement of insulin or C-peptide levels or by inference through documentary episodes of ketosis or a history of insulin use equal in length to the duration of diabetes. Diabetes secondary to other conditions can only be established by clinical workup or medical history to determine the presence of the other condition. If IDDM and secondary diabetes can be excluded, patients that meet the diagnostic criteria for diabetes can be presumed to be NIDDM.

The criteria for diagnosis of diabetes doubtless need verification. For example, it is uncertain whether persons with high fasting blood glucose levels are at a different risk of developing complications than are persons whose fasting level is below 140 mg/dl but who exhibit glucose intolerance during the oral glucose tolerance test. A Japanese study found the fasting value to be more predictive of mortality than the 2-hour value (Sasaki 1981), while in the Pima Indians the 2-hour value was superior in predicting retinopathy and nephropathy (Pettit et al. 1980). Further research is needed to quantify these risks. In addition, further research is needed to determine whether blood glucose levels should continue to be the basis for diagnosing diabetes, or whether some other measure more accurately predicts the complications of diabetes.

Table 4 lists the criteria for gestational diabetes used most commonly in the United States. These criteria were promulgated in 1964 (O'Sullivan and Mahan 1964), and no data have been put forward to recommend their change.

TABLE 4. *Criteria for diagnosis of gestational diabetes*

Two or more of the following glucose concentrations (fasting value and values at times after a 100-gram oral glucose dose) must be met or exceeded:

	venous plasma	venous whole blood	capillary whole blood
Fasting	105 mg/dl (5.8 mmol/L)	90 mg/dl (5.0 mmol/L)	90 mg/dl (5.0 mmol/L)
1 hour	190 mg/dl (10.6 mmol/L)	170 mg/dl (9.4 mmol/L)	190 mg/dl (9.4 mmol/L)
2 hour	165 mg/dl (9.2 mmol/L)	145 mg/dl (8.1 mmol/L)	165 mg/dl (8.1 mmol/L)
3 hour	145 mg/dl (8.1 mmol/L)	125 mg/dl (6.9 mmol/L)	145 mg/dl (6.9 mmol/L)

SOURCE: O'Sullivan, JM, and CM Mahan. Criteria for the oral glucose tolerance test in pregnancy. Diabetes 13:278, 1964.

IMPAIRED GLUCOSE TOLERANCE (IGT)

Impaired glucose tolerance (IGT) is a term defined by the NDDG (1979) and subsequently adopted by the WHO (1980) to encompass persons whose fasting plasma glucose concentration is less than that required for a diagnosis of diabetes (less than 140 mg/dl) and whose plasma glucose value at 2 hours after a 75-gram oral glucose challenge is intermediate between nondiabetic and diabetic (between 140 and 200 mg/dl). Thus the IGT class is defined not by clinical manifestations, but by plasma glucose criteria, and an oral glucose tolerance test (75 gm of oral glucose) is required to place an individual in this class. The term "impaired glucose tolerance" replaces the older terms "borderline diabetes" and "chemical diabetes," which are now considered inappropriate because they invoke social, psychologic, and economic sanctions that are unjustified in light of the lack of severity of glucose intolerance in these persons.

There are some differences between the NDDG and WHO criteria for classifying persons as IGTs. While both require the fasting and 2-hour values shown in Table 5, the NDDG also requires that the person's plasma glucose value equal or exceed 200 mg/dl at some time between zero time and 2 hours after the glucose challenge. WHO criteria do not use this midtest value, and persons are categorized based only on their fasting and 2-hour values. (There is also a modification of these criteria in Table 5, wherein only the 2-hour postglucose value is used, that is considered acceptable for epidemiologic studies.) Use of the midtest value radically changes the prevalence of IGT. Only about one-half of persons classed as IGT by WHO criteria are also classed as IGT by NDDG. The remainder are nondiagnostic, primarily because the mid-test glucose value is lower than 200 mg/dl (Hadden et al. 1985).

Several lines of evidence indicate that persons with IGT have a higher risk of developing diabetes and are intermediate between normal and diabetic in risk of developing the macrovascular complications of diabetes. This evidence includes prospective studies on the Pima Indians showing that, over time, persons develop diabetes at a rate proportional to their initial plasma glucose concentration measured 2 hours after a 75-gram oral glucose challenge (Hamman et al. 1978). Several other studies have shown that persons who fall into the IGT class have a higher risk of developing diabetes, with about 1 percent to 5 percent becoming diabetic each year compared to less than 1 percent of persons classed as normal (Fitzgerald and Malins 1976, Keen et al. 1982, O'Sullivan and Mahan 1968). However, these studies also showed that, even after 10 years, the majority of persons remain in the IGT class, and a significant proportion revert to normal. In the Pima Indian study, microvascular complications rarely occurred in persons with IGT (Pettit et al. 1980), and, in a British study, persons with IGT also appeared to have little or no evidence of the microvascular disease found in diabetics. However, in the latter, mortality rates were higher than those experienced by nondiabetics; much of the excess death appeared to be due to cardiovascular diseases (Al Sayegh and Jarrett 1974). The clinical significance of IGT and its prognostic significance for the development of complications hence remain to be fully investigated.

THE ORAL GLUCOSE TOLERANCE TEST (OGTT)

In symptomatic individuals with random plasma glucose values greater than 200 mg/dl, the OGTT may not be required for a diagnosis of diabetes. However, in asymptomatic individuals and to establish a diagnosis of IGT, the OGTT is necessary. The test should be performed in the morning on subjects who have had at least 3 days of unrestricted diet. The subject should have fasted between 10 and 16 hours, during which time only water was permitted. The subject should remain seated and not smoke throughout the test. A fasting blood sample should be collected, after which the subject should drink 75 grams of glucose in a concentration no greater than 25 grams per 100 ml. Commercially prepared carbohydrate loads equivalent to this are available. Additional blood samples should be taken at midtest (1/2 hour, 1 hour, or 1-1/2 hours) and at 2 hours. If this is not feasible in an epidemiologic or survey setting, a single 2-hour blood sample can be considered adequate.

TABLE 5. *Criteria for diagnosis of impaired glucose tolerance: Recommendations of the National Diabetes Data Group (NDDG) and the World Health Organization (WHO)*

I. In a Clinical Setting

The NDDG requires that the three criteria A, B, and C must be met. The WHO requires only that criteria A and B be met.

A. Fasting glucose concentration:

venous plasma < 140 mg/dl (7.8 mmol/L)
venous whole blood < 120 mg/dl (6.7 mmol/L)
capillary whole blood < 120 mg/dl (6.7 mmol/L)

B. Glucose concentration at 2 hours after ingesting 75 grams of oral glucose:

venous plasma between 140 and 200 mg/dl (7.8 and 11.1 mmol/L)
venous whole blood between 120 and 180 mg/dl (6.7 and 10.0 mmol/L)
capillary whole blood between 140 and 200 mg/dl (7.8 and 11.1 mmol/L)

C. Glucose concentration at midtest (1/2 hour, 1 hour, or 1 1/2 hours) after ingesting 75 grams of oral glucose:

venous plasma ≥ 200 mg/dl (11.1 mmol/L)
venous whole blood ≥ 180 mg/dl (10.0 mmol/L)
capillary whole blood ≥ 200 mg/dl (11.1 mmol/L)

II. In an Epidemiologic Setting

In epidemiologic studies on diabetes, it may be impossible or impractical to meet the requirement of obtaining two or three blood samples. Consequently a modification is recommended whereby a single blood sample should be drawn 2 hours after a 75-gram oral glucose challenge. If the glucose concentration meets the criteria below, the individual may be assigned to the IGT class for epidemiologic purposes. However, this results in twice the prevalence of IGT that is obtained when the midtest value is also imposed.

Glucose concentration at 2 hours after ingesting 75-gram oral glucose:

venous plasma between 140 and 200 mg/dl (7.8 and 11.1 mmol/L)
venous whole blood between 120 and 180 mg/dl (6.7 and 10.0 mmol/L)
capillary whole blood between 140 and 200 mg/dl (7.8 and 11.1 mmol/L)

TABLE REFERENCES

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STATISTICAL RISK CLASSES

Two classes encompassing persons at a higher statistical risk of developing diabetes have been defined (NDDG 1979), previous abnormality of glucose tolerance (Prev AGT) and potential abnormality of glucose tolerance (Pot AGT). The former comprises persons who now exhibit normal glucose tolerance, but who, in the past, have exhibited elevated glucose levels, for example during severe burns or after a myocardial infarction. It is believed that these persons will again develop hyperglycemia if subjected to such stresses, but little data exist to substantiate this. The latter category comprises persons who also have normal glucose tolerance but who are believed to be at higher risk of developing diabetes for a number of reasons. These include such characteristics as a family history of diabetes, HLA antigens D3 and D4 or islet cell antibodies, obesity, and a medical history of having given birth to a heavy baby.

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CHAPTER III. INCIDENCE AND RISK FACTORS FOR INSULIN-DEPENDENT DIABETES

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SUMMARY

The annual incidence of insulin-dependent diabetes mellitus (IDDM) in the United States is about 12-14 new cases per 100,000 children ages 0-16 years. By age 20, about 0.3 percent of persons have developed IDDM. The risk for developing IDDM is higher than most chronic diseases of childhood. Incidence rates are about equal for males and females, but are 1.5 times higher in whites than in blacks. Siblings of diabetic children have a 7 to 18-fold greater risk of developing IDDM than children in the general population, although only about 1 child in 50 who is a brother or sister of an IDDM patient will develop IDDM.

IDDM COMPARED TO OTHER CHRONIC DISEASES OF CHILDREN

It is essential to indicate briefly the importance of IDDM as a chronic disease in children. Typically, IDDM incidence is compared to the incidence of noninsulin-dependent diabetes, which makes the problem of IDDM appear small because only about 5 percent of all diabetes in the United States is of the insulin-dependent type. This is, however, an inappropriate comparison because of major differences in their ages of onset. More appropriate is the comparison of IDDM risk to incidence of other chronic diseases in children. This comparison reveals that the risk of developing IDDM is similar to the risk of developing cancer in childhood but is much greater than for other well-known diseases such as cystic fibrosis, muscular dystrophy, rheumatoid arthritis, leukemia and Hodgkin's disease (Table 1). Thus, IDDM should be considered one of the most important chronic diseases of children.

INCIDENCE OF IDDM IN THE UNITED STATES

Only recently, with the establishment of accurate registries, have researchers been able to determine the incidence (number of new cases) of IDDM. Even with these registries, the risk for developing IDDM in the United States, as well as the descriptive epidemiology of IDDM, have not been well established. The annual incidence rates

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TABLE 1. *Risk of IDDM compared to other chronic diseases of children under age 16 years*

Disease	Rate Per 100,000 Children
IDDM	11.5
Cystic fibrosis	3.1
Nephrotic syndrome	1.3
Peptic ulcer	3.5
Lupus erythematosus	0.2
Juvenile rheumatoid arthritis	3.0
Muscular dystrophy	1.1
Multiple sclerosis	3.0
Cancer (age <15 years)	12.2
Leukemia	3.9
Brain	2.6
Lymphoma	1.3
Other cancers	4.8

SOURCES: Cancer: Third National Cancer Survey: Incidence data. National Cancer Institute Monograph 41. DHEW Pub. No. (NIH) 75-787, 1975. Kurland, LT. Multiple sclerosis: The frequency and geographic distribution of multiple sclerosis as indicated by mortality statistics and morbidity surveys in the United States and Canada. Am J Hyg 55:457-76, 1952. All other: Sultz, HA, ER Schlesinger, WE Mosher, and JG Feldman. Long-term Childhood Illness. Pittsburgh: University of Pittsburgh Press, 1972. pp. 223-48.

reported from studies with good ascertainment of IDDM are relatively consistent and indicate that the risk for IDDM prior to age 20 is about 12-14 per 100,000 children per year (Table 2). Estimates of the cumulative risk in Allegheny County, Pennsylvania indicate that a child has about a 0.3 percent risk of developing IDDM by age 20, i.e., about 0.3 percent of persons have developed IDDM by this age, with blacks having a risk that is about 50 percent that of whites (LaPorte et al. 1985b).

There are five geographic areas in the United States where incidence studies have been completed (Table 2). The earliest study, in Erie County, New York was designed to investigate long-term childhood illness in general, and there appeared to be problems in ascertainment of IDDM. However, it is the only study that permits comparison with incidence of other chronic diseases in children. The studies in Rochester, Minnesota provide data on the largest range of age at onset of IDDM, although they are somewhat limited because the sample size is quite small. The registry from Allegheny County is currently the largest ongoing IDDM registry and provides important data concerning the incidence of IDDM in a defined community. However, the Allegheny County registry only includes individuals who were less than 20 years of age at onset of IDDM. The Rhode Island registry has investigated IDDM incidence for ages up to 30 years, but has published data for only a 1-year period. The data from Baltimore, Maryland appear to be severely hampered by under-ascertainment. Currently an incidence registry is being developed in Colorado.

TABLE 2. *Incidence studies of IDDM*

Reference	Population	Age Range (Years)	Date Studied	Number of Cases	Annual Incidence Per 100,000 Persons
United States					
a	Erie County, NY	0-15	1960-69	366	11.5*
b,c	Rochester, MN	0-29	1960-69	24	12.3
d	Allegheny County, PA	0-19	1965-80	1,176	14.7
e	Rhode Island	0-29	1979-80	35	12.4
f	Baltimore, MD	0-17	1960-76	846	2-11*
Outside United States					
g	Tokyo, Japan	Elementary/junior high students	1974-78	11	0.8
h	Midwest Poland	0-15	1970-81	294	3.6
			1982-83	80	6.4
i	France	0-14	1975	465	3.7*
j	England	0-15	1973-74	2,274	7.7*
k	England	0-15	1958-73	22	8.9
l	Norway	0-19	1946-64	176	3-13
m	Montreal, Canada	0-16	1971-77	522	8.8
n	Toronto, Canada	0-17	1976-78	132	9.0*
o	British towns	18-50	1977-79	87	8-10
p	New Zealand	0-19	1968-72	578	10.4
q	Denmark	0-29	1970-74	474	13.2
r	Scotland	0-18	1968-76	2,505	13.8
s	Norway	0-14	1973-77	845	17.6
t	Sweden	0-15	1970-75	359	19.6
u	Sweden	0-14	1977-80	369	22.6
v	Finland	0-19	1946-64	176	30
w	Finland	0-14	1976-77	-	27.9
x	Northern Sweden	0-14	1938-42	307	14.2**
			1973-77		37.9***

*Ascertainment problems.

**Ill-defined denominator.

***Rate probably overestimated.

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INTERNATIONAL IDDM INCIDENCE RATES

The risk for developing IDDM is known for less than 2 percent of the world's population (LaPorte et al. 1985a). Accurate data have primarily been generated in European countries, where IDDM registries are generally much easier to establish than in the United States because of centralization of medical records and insulin prescriptions. Comparison of United States rates with those of other countries indicates that the IDDM rate in the United States is lower than that of the Scandinavian countries, similar to that of the non-Scandinavian countries, and higher than that of the Asian countries (Table 2). There is substantial variation in the incidence of IDDM across the world, from rates less than the 0.8/100,000 in Japan to rates over 34 times higher (27.9/100,000) in Finland. Although some of the difference in rates is the result of under-ascertainment, it is unlikely that this can explain the large variability across populations. The data, therefore, suggest true geographic/racial differences in the risk of developing IDDM.

TIME TRENDS IN INCIDENCE OF IDDM

The data are contradictory concerning secular changes in the risk for developing IDDM. There is little evidence for a change in IDDM incidence rates during 1965-80 in Allegheny County (Table 3). In addition, no secular increase was found in Rochester (Palumbo et al. 1976, Melton et al. 1983) and in most European studies. Two reports indicated that the incidence of IDDM was increasing (Hagglof et al. 1982, Sultz et al. 1972), but this is likely to be an artifact due to under-ascertainment of IDDM in the early years of study. However, there appears to be a true increase in IDDM in Denmark (Green et al. 1981) and Poland (Rewers et al. 1984).

SEX DIFFERENCES

There is little evidence for major differences in the risk of IDDM by sex. The incidence of IDDM was slightly higher in females than males in Erie County (Sultz et al. 1972). In Allegheny County, a modest increased risk for white males was found (Table 4), and similar results have been published from most European studies.

TABLE 3. *Time trends in annual age-adjusted IDDM incidence rate per 100,000 persons and 95 percent confidence interval (CI), ages 0-19 years, Allegheny County, Pennsylvania*

Years of Study	White Males Rate	(CI)	White Females Rate	(CI)	Nonwhite Males Rate	(CI)	Nonwhite Females Rate	(CI)
1965-67	12.7	(2.5)	9.5	(2.2)	6.0	(5.6)	14.4	(8.2)
1968-70	17.0	(2.9)	17.0	(3.0)	5.8	(5.1)	8.8	(6.1)
1971-73	18.6	(3.2)	14.4	(2.8)	9.9	(6.5)	7.8	(5.8)
1974-76	16.8	(3.2)	18.7	(3.4)	13.8	(7.8)	12.5	(7.4)
1977-80	15.6	(2.9)	14.6	(2.9)	8.4	(5.2)	8.5	(5.3)
1965-80	16.1	(1.3)	14.8	(1.3)	8.9	(2.7)	10.3	(2.9)

SOURCE: LaPorte, RE. Unpublished data.

TABLE 4. *Age/race/sex-specific IDDM annual incidence rate per 100,000 persons and 95 percent confidence interval (CI), Allegheny County, Pennsylvania, 1965-1980*

Age (Years)	White Males Rate (CI)	White Females Rate (CI)	Nonwhite Males Rate (CI)	Nonwhite Females Rate (CI)
<5	6.2 (1.8)	6.8 (1.9)	4.4 (3.8)	4.4 (3.9)
5-9	17.8 (2.8)	16.6 (2.8)	6.4 (4.5)	5.8 (4.3)
10-14	21.2 (2.9)	23.7 (3.1)	11.7 (6.0)	18.2 (7.4)
15-19	16.7 (2.6)	9.8 (2.0)	11.9 (6.3)	10.6 (5.7)
Age-adjusted rate	16.1 (1.3)	14.8 (1.3)	8.9 (2.7)	10.3 (2.9)

SOURCE: LaPorte, RE. Unpublished data.

RACE DIFFERENCES

Only two studies in the United States have examined the risk of IDDM comparing whites with blacks. In Allegheny County, whites were about 1.5 times more likely to develop IDDM than blacks (Table 4). A similar ratio occurred in Erie County (Sultz et al. 1972). No diabetes in children 0-14 years of age has been found in certain American Indian tribes such as the Pimas (Savage et al. 1979).

SOCIOECONOMIC RELATIONSHIP

There are conflicting reports concerning whether IDDM is associated with socioeconomic status. In Denmark, lower socioeconomic groups appeared to have an increased risk (Christau et al. 1977), while in Montreal, higher socioeconomic groups had an increased risk (West et al. 1979). In Allegheny County (Table 5) and in Erie County (Sultz et al. 1972), there was little evidence for an increased risk by socioeconomic status.

TABLE 5. *IDDM incidence rates by socioeconomic status, Allegheny County, Pennsylvania, 1965-80*

		Whites		Nonwhites	
Age (Years)	Socio-Economic Class	Average 1970 Family Income	Incidence Per 100,000 Persons	Average 1970 Family Income	Incidence Per 100,000 Persons
<5	1	$8,143	8.47	$3,586	5.34
5-9			13.14		4.97
10-14			21.38		16.90
15-19			10.19		10.01
		Age-adjusted rate -	13.74	Age-adjusted rate -	9.73
<5	2	$9,420	6.50	$5,148	6.00
5-9			14.10		12.18
10-14			18.70		12.10
15-19			10.47		19.57
		Age-adjusted rate -	12.89	Age-adjusted rate -	12.81
<5	3	$10,463	5.22	$6,136	3.06
5-9			16.31		0.00
10-14			21.17		12.01
15-19			14.54		5.62
		Age-adjusted rate -	14.94	Age-adjusted rate -	5.49
<5	4	$11,664	7.50	$7,333	0.00
5-9			17.40		5.41
10-14			20.72		7.36
15-19			10.72		8.69
		Age-adjusted rate -	14.56	Age-adjusted rate -	5.70
<5	5	$15,208	6.58	$9,728	9.18
5-9			16.56		8.23
10-14			22.11		30.65
15-19			14.37		9.03
		Age-adjusted rate -	15.51	Age-adjusted rate -	14.98

SOURCE: LaPorte, RE, et al. The Pittsburgh insulin-dependent diabetes mellitus registry: relationship of IDDM incidence to social class. Am J Epidemiol 114:379-84, 1981.

AGE AT ONSET

Figure 1 illustrates age at onset data for male and female diabetics diagnosed prior to age 20 in Allegheny County. Peak incidence occurred around puberty, with males having a later peak than females. These age at onset curves are similar to those of Japan, despite the almost 18-fold difference in risk of developing IDDM (Tajima et al. 1985).

There is little accurate information concerning incidence of IDDM in adulthood, primarily because of the difficulty in discriminating between NIDDM and IDDM. In three studies, while the highest rates occurred in younger age groups, the IDDM risk was still substantial at older ages, even though the sample sizes on which the rates were based were quite small (Table 6). The development of classical IDDM at older ages is therefore an important area of investigation.

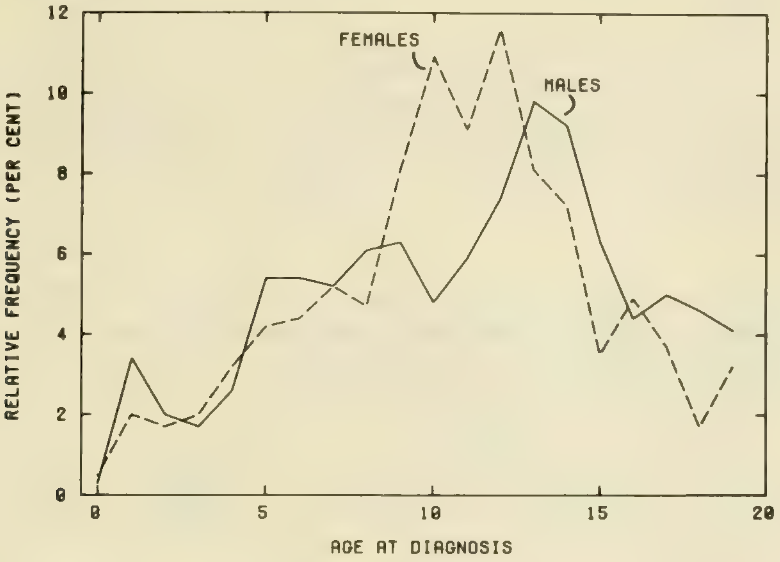

FIGURE 1. *Age at onset of IDDM for white males and females*

SOURCE: LaPorte, RE, HA Fishbein, AL Drash et al. The Pittsburgh insulin-dependent diabetes mellitus (IDDM) registry: The incidence of insulin-dependent diabetes mellitus in Allegheny County, Pennsylvania (1965-1976). Diabetes 31:270-84, 1981.

RISK FACTORS FOR IDDM

Family History of Diabetes

IDDM is a disorder that tends to run in families but does not have a clear genetic etiology or a consistent mode of inheritance (Neel 1976). There is strong evidence, however, that relatives of IDDM patients are at a greatly increased risk for development of IDDM. In Allegheny County, the risk of IDDM in siblings of children with diabetes ranged between 7 and 17.5 times that of the general population, indicating that the brother or sister of a diabetic child was at a strikingly increased risk for diabetes (Table 7). However, this risk of developing IDDM is still extremely small, as only about

TABLE 6. *Age-specific IDDM incidence rate per 100,000 persons and number of IDDM cases (N), United States, 1960-80*

Age at Onset (Years)	Allegheny County, PA, 1965-80		Rhode Island, 1979-80		Rochester, MN 1960-69	
	Rate	(N)	Rate	(N)	Rate	(N)
<5	6.2	(110)	6	(3)	-	-
5-9	15.8	(311)	13	(9)	-	-
<9	-	-	-	-	7.4	(15)
10-14	21.5	(480)	19	(14)	-	-
15-19	13.0	(283)	11	(9)	-	-
10-19	-	-	-	-	8.7	(13)
20-24	-	-	14	(12)	-	-
25-29	-	-	17	(14)	-	-
20-29	-	-	-	-	5.2	(8)
30-39	-	-	-	-	4.0	(5)
40-49	-	-	-	-	10.7	(11)
50-59	-	-	-	-	10.5	(9)
60-69	-	-	-	-	9.4	(6)
70+	-	-	-	-	15.2	(8)

SOURCES: Allegheny County: LaPorte, RE. Unpublished data. Rhode Island: Fishbein, HA, GA Faich, and SE Ellis. Incidence and hospitalization patterns of insulin-dependent diabetes mellitus. Diabetes Care 5:630-33, 1982. Rochester: Melton, LJ, PJ Palumbo, and CP Chu. Incidence of diabetes mellitus by clinical type. Diabetes Care 6:75-86, 1983.

TABLE 7. *Age-specific IDDM annual incidence rate per 100,000 persons for siblings of index IDDM patients (1965-1980) and for the general Pittsburgh population (1965-1976)*

Age (Years)	Siblings			General Population Rate	Relative Risk
	Person-Years of Study	Number of Cases	Rate		
Index IDDM patient age at onset = all ages					
0-4	12,144	6	49.41	6.25	7.9
5-9	11,333	14	123.53	17.71	7.0
10-14	9,660	37	383.02	21.88	17.5
15-19	6,767	8	118.22	11.71	10.1
Index IDDM patient age of onset less than 10 years					
0-4	6,039	4	66.24	6.25	10.6
5-9	5,414	8	147.77	17.71	8.3
10-14	4,454	16	359.23	21.88	16.4
15-19	2,873	2	69.61	11.71	5.9
Index IDDM patient age of onset at least 10 years					
0-4	6,105	2	32.76	6.25	5.2
5-9	5,919	6	101.37	17.71	5.7
10-14	5,206	21	403.38	21.88	18.4
15-19	3,894	6	154.08	11.71	13.2

SOURCE: Wagener, D, et al. Pittsburgh diabetes mellitus study: secondary attack rates in families with IDDM. Am J Epidemiol 115:868-78, 1982.

one child in 50 who is a brother or sister of an IDDM patient will develop diabetes before age 20. Of 81 identical twin pairs in which one twin developed IDDM before age 20, 34 (42 percent) of their co-twins did not have diabetes (Barnett et al. 1981).

Maternal Age

Maternal age appears to be associated with the development of diabetes (Wagener et al. 1983, Flood et al. 1982), as children born after their mothers were over age 35 were about twice as likely to develop IDDM as children who had younger mothers (Figure 2). Reasons for this association are not known but may relate to some form of in utero exposure.

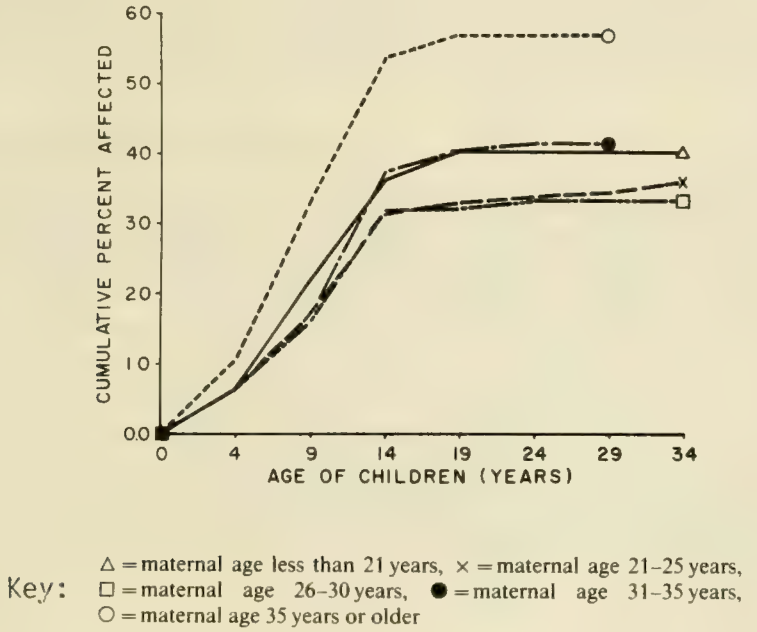

FIGURE 2. *The cumulative frequency of IDDM in children, grouped according to age of the mother at birth of the child*

SOURCE: Wagener, DK, RE LaPorte, TJ Orchard, DE Cavender, LH Kuller, and AL Drash. The Pittsburgh diabetes mellitus study. III. An increased prevalence with older maternal age. Diabetologia 25:82–85, 1983.

Genetic Markers

The relationships of various genetic markers to the risk of developing IDDM have been extensively reviewed (Rotter 1981, Svejgaard et al. 1980). The risk is highly associated with the human leukocyte antigen (HLA) system, a series of genetic markers identified on tissues and assessed using white blood cells. The HLA system appears to be related to chronic disorders with unclear etiologies that may have an autoimmune basis. It has been hypothesized that IDDM is an autoimmune disease in which the immune system produces antibodies that attack the pancreas, destroying the insulin-producing beta cells.

The HLA system seems to be related to onset of IDDM, as individuals with certain HLA types are at significantly increased risk for the development of IDDM (Table 8). For example, individuals with B8 are about 2.6 times more likely to develop IDDM than those who do not have B8. The association of HLA type and IDDM is strongest for the DR HLA types, suggesting that the DR region may be the critical region associated with increased risk for diabetes (Table 9). Individuals with DR3/DR4 have a 46-fold increased risk for developing IDDM when compared to the general population. The reason these markers are associated with IDDM has not been established and is the focus of research throughout the world. Other markers, including Bf, Kidd, DQ, and DP, have been thought to be associated with IDDM.

TABLE 8. *Relative risk of IDDM for persons with certain HLA antigens*

		IDDM Patients		Nondiabetics			
HLA Type	Number of Studies	Number	Percent With HLA	Number	Percent With HLA	Relative Risk	P-Value
B8	18	1,785	19-60	13,349	2-29	2.56	$<1^{-10}$
B15	17	1,769	4-50	13,175	2-26	2.05	$<1^{-10}$
B18	13	1,244	5-59	6,577	5-50	1.69	4×10^{-8}
B7	14	1,493	3-29	7,677	3-32	0.54	$<1^{-10}$
DR2	--	93	3.2	260	25.4	0.1	3×10^{-7}
DR3	--	93	53.8	260	28.8	2.9	1×10^{-5}
DR4	--	93	72.0	260	32.3	5.4	$<10^{-10}$

SOURCE: Nerup, J, M Christy, A Green, M Hauge, P Platz, LP Ryder, A Svejgaard, and M Thomsen. HLA and insulin-dependent diabetes - population studies. In: Kobberling, J, and R Tattersall, eds. The Genetics of Diabetes Mellitus. Serono Symposium No. 47. London and New York: Academic Press, 1982.

TABLE 9. *Relative risk of IDDM for persons with certain combinations of HLA antigens*

	Number Studied				
Genotype*	Nondiabetic	IDDM	Relative Risk	95% Confidence Interval	P-Value
DR3/3	4	7	32.3	7.6, 136.8	3×10^{-3}
DR3/x	49	19	7.1	2.8, 18.1	NS
DR3/4	14	35	46.1	17.3, 122.9	$<10^{-10}$
DR4/x	61	55	16.6	7.1, 38.6	2×10^{-4}
DR4/4	6	11	33.8	9.6, 118.2	9×10^{-5}
DRx/x	129	7			4×10^{-10}

*x is any antigen other than DR3 or DR4

SOURCE: Barbosa, J, FH Bach, and SS Rich. Genetic heterogeneity of diabetes and HLA. Clinical Genetics 22:25-32, 1982.

Viruses

The seasonal pattern of IDDM onset has been suggested to imply a viral etiology for IDDM because viruses also have distinctive seasonal trends. The strongest evidence was from study of a child who died shortly after the onset of IDDM; Coxsackie virus isolated from the pancreas of the child produced diabetes when injected into mice (Yoon et al. 1979). On a population basis, however, there is little evidence that viral infections account for a large proportion of cases. Many investigators suspect that a single, specific viral infection is unlikely to produce diabetes. Instead, IDDM may result from the cumulative effects of different viral infections. The techniques for evaluating the multiple hit model of a viral etiology for IDDM have not been well established. In general, the current belief is that a viral etiology could probably not account for the majority of cases of IDDM (Gamble 1980, Craighead 1981, Champsaur et al. 1982).

Autoimmunity and Islet Cell Antibodies

There is strong evidence that most IDDM patients have autoantibodies to the pancreas at onset of IDDM that are specific to the insulin-secreting islet cells (Lernmark et al. 1981). Islet cell antibodies (ICA) may be responsible for pancreatic destruction or may only serve as markers for tissue damage that occurred by another mechanism. For example, it has been hypothesized that viruses interact with the immune system to produce injury to the pancreas through the host's response to the virus. Nondiabetic siblings of children with IDDM have also demonstrated ICA. Some of these children later developed IDDM, suggesting that pancreatic damage occurred long before the onset of clinical symptoms (Gorsuch et al. 1982) and that ICA may be a predictor of onset of IDDM. However, not until a large number of individuals are studied will it be possible to determine whether ICA is associated with IDDM prior to onset.

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CHAPTER IV. INCIDENCE AND RISK FACTORS FOR NONINSULIN-DEPENDENT DIABETES

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and Peter H. Bennett, M.B., F.F.C.M., F.R.C.P.

SUMMARY

The incidence of noninsulin-dependent diabetes (NIDDM) in the United States, based on national interview surveys which ascertain self-reported physician-diagnosed diabetes, is about 32 new cases per 10,000 population ages 20 years and older per year. Incidence rates in all age groups increased between 1935 and 1973, but since then they have remained stable or declined. Rates increase with age for both sexes; above age 25, incidence in females is about 20 percent higher than in males. About 500,000 new cases of NIDDM occur each year in persons age 25 years and older.

In the United States, rates of NIDDM are high among blacks, Mexican Americans, and American Indians. Rates also vary by urban or rural habitation, degree of modernization, and socioeconomic status. The most important risk factors for development of NIDDM are increasing age, higher blood glucose concentration, family history of diabetes, and obesity. While many risk factors for NIDDM have been identified, it remains unknown whether intervention in these would prevent or delay development of NIDDM.

METHODS FOR DETERMINING INCIDENCE RATES AND RISK FACTORS

The rate of development of disease can be determined by measuring incidence, which is the number of new cases of illness occurring in a specified population at risk per unit time. Demonstration that a certain attribute is a "risk factor" for a disease is best determined by documenting a higher incidence rate in persons with the factor than in those without it. Whether a risk factor is causative, however, can only be concluded if reduction of that factor reduces the incidence of the disease.

Risk factors for a disease can also be inferred from prevalence, that is, the proportion of subjects having the disease at a specific time. If prevalence is greater in a group which has a particular attribute than in another lacking it, this attribute may be a risk

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factor. For immutable attributes such as genetic determinants, and for characteristics that can be demonstrated or unequivocally assumed to be present before the development of the disease, prevalence studies may be used to infer risk provided that the factor does not affect survival after diagnosis of the disease.

In general, incidence studies are preferred for determining risk factors for disease, especially in situations where a risk factor may change over time or after onset of the disease. For example, the degree of obesity may diminish appreciably after development of NIDDM, as a result of either the natural history of the disease or therapeutic intervention. If only prevalence data were available, misleading conclusions could be made concerning obesity as a risk factor for NIDDM.

There are two common methods for computing incidence rates. One is the person-year method, in which each subject without the disease is studied until disease onset or until the end of the study if disease does not occur; incidence is then the number of new cases per person-year without the disease. In some studies such as that in Rochester, Minnesota, person-years at risk were determined from a community census or registry that did not exclude those with the disease. Person-years contributed by cases after disease development allow an acceptable approximation of time at risk when the incidence rate of the disease is low. Alternatively, a fixed population can be studied at two separate times, and the cumulative incidence rate in the interim calculated by dividing the number who have developed the disease by the end of the study by the number without the disease at the beginning of the study. An approximation of incidence per person-year can then be made by dividing the cumulative incidence rate by the length of the study period. For studies with very high incidence rates or long time periods, a more accurate formula should be used (Miettinen 1976).

In examining the influence of risk factors on development of diabetes, the impact of individual factors may be examined one at a time (univariate analysis) or the individual effects of two or more may be considered simultaneously (multivariate analysis). Interpretation of multivariate analyses is sometimes difficult, since results depend on the precision with which a variable is measured as well as the force it exerts on development of disease, both of which are weighted in statistical analysis. Thus, a factor that shows the strongest statistical contribution to incidence may not be the most important biological risk factor. Also, a factor that shows a statistically significant contribution to risk is not necessarily directly involved in development of disease, as it may be a surrogate for a more important factor. Further, multivariate analysis does not account for the time between exposure to the factor and development of the disease, which is important in considering causation. In this chapter, an independent risk factor is defined as a variable in a multivariate analysis that contributes significantly to a statistical model for determining risk factors after adjustment for other risk factors is made.

Reports of diabetes incidence rates and risk factors must be interpreted with caution. Before conclusions are drawn, the methods of the study should be examined as to the characteristics of the observed population, possible selection biases, means of diagnosis, and method of incidence and risk calculation.

INCIDENCE OF NIDDM

Table 1 summarizes incidence studies of glucose intolerance in adults in the United States and selected other locations. Because diabetes incidence generally increases

TABLE 1. *Incidence studies of glucose intolerance in adults*

Reference	Population and Study	Diagnostic Criteria	Date	Number of Incident Cases Studied	Age at Diagnosis	Sex	Annual Incidence Per 1,000 Persons	Age-Adjusted* Incidence Per 1,000 Persons Ages 40+ Years
National Interview Surveys								
a	U.S., National Health Survey	Physician-diagnosed diabetes reported in a household interview	1935-36	874	25+	Male	.43	.69
						Female	.76	1.17
b	U.S., National Health Interview Survey	Same as above	1978	-	All ages	Male	19.1	-
						Female	33.7	-
b	U.S., National Health Interview Survey	Same as above	1979-81	230	20+	Male	31.7	55.3
						Female	32.2	45.8
Local Populations, Laboratory/Clinical Criteria**								
c	Oxford, Massachusetts	Glycosuria and postprandial blood glucose ≥200; or postprandial >170 with retest >140	1946-60	16	34-55	Both sexes	1.1	
d	Rochester, Minnesota	About 81% diagnosed by fasting blood glucose >110; remainder by 2-hour post glucose >110-140; medical chart review	1945-70	1,099	All ages	Male	1.2	2.0
						Female	1.1	1.4
e	Employed northeastern Caucasians	Clinical diagnosis, or fasting blood glucose >130, or postprandial >170	1954-64	249	30-59	Male	6.1	6.7
f	Framingham, Massachusetts	100 g GTT; 1-hour >205, 2-hour >140; or insulin treatment; or oral agents with casual glucose >150	1954-68	274	33-67	Male	4.8	
						Female	3.9	
g	Choctaw Indians	Chart review; fasting blood glucose >130, or 2-hour venous blood glucose >150	1956-61	175	All ages	Both sexes		
	Full heritage					Full	11.1	20.1
	Mixed heritage					Mixed	4.7	17.5
h	Tecumseh, Michigan	Physician-diagnosed diabetes and insulin or orals use; or diabetes on death certificate; or blood glucose score post 100-gm glucose	1959-79	184	20+	Male	2.8	4.3
						Female	3.0	5.5

TABLE 1. (Continued)

Reference	Population and Study	Diagnostic Criteria	Date	Number of Incident Cases Studied	Age at Diagnosis	Sex	Annual Incidence Per 1,000 Persons	Age-Adjusted* Incidence Per 1,000 Persons Ages 40+ Years
i	Israeli civil servants	Clinical diagnosis; or 1 gm/kg OGTT, fasting ≥120, 1-hour ≥180, 2-hour ≥130	1963-68	373	40+	Male	8.0	9.4
Local Populations, NDDG/WHO Criteria								
j	Pima Indians	75-gm OGTT, 2-hour plasma glucose >200	1965-75	234	5+	Male	16.4	36.1
						Female	20.1	49.5
k	Nauru, South Pacific	75-gm OGTT, 2-hour plasma glucose >200	1975-82	27	All ages	Male	11.0	16.8
						Female	9.5	11.3

*Age-adjusted by direct standardization to the 1980 United States population ages 40+ years, except the 1935-36 national survey and Pima Indian study (rates were for ages 35+ years) and the 1979-81 national survey (rates were for ages 45+ years). Cumulative incidence rate method used for Oxford, Israeli, and Nauruan studies, the person-year method in the other studies.

**Glucose concentrations expressed in mg/dl

TABLE REFERENCES

a. Spiegelman, M, and HH Marks. Age and sex variations in the prevalence and onset of diabetes mellitus. Am J Pub Health 36:26-33, 1946.

b. Drury, TF. Unpublished data from the 1979-81 National Health Interview Surveys, National Center for Health Statistics.

c. O'Sullivan, JB. Population retested for diabetes after 17 years: New prevalence study in Oxford, Massachusetts. Diabetologia 5:211-14, 1969.

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e. Dunn, JP, J Ipsen, KO Elsom, and M Ohtani. Risk factors in coronary artery disease, hypertension and diabetes. Am J Medical Sciences 259:309-22, 1970.

f. Wilson, PW, DL McGee, and WB Kannel. Obesity, very low density lipoproteins, and glucose intolerance over fourteen years: The Framingham Study. Am J Epidemiol 114:697-704, 1981.

g. Drevets, CC. Diabetes mellitus in Choctaw Indians. J Okla Med Assoc 58:322-29, 1965.

h. Butler, WJ, LD Ostrander, Jr, WJ Carman, and DE Lamphiear. Diabetes mellitus in Tecumseh, Michigan. Am J Epidemiol 116:971-80, 1982.

i. Medalie, JH, Herman, U Goldbourt, and CM Papier. Variations in incidence of diabetes among 10,000 adult Israeli males and the factors related to their development. In: Levine, R, and R Luft, eds. Advances in Metabolic Disorders. New York: Academic Press, 1978. pp 93-110.

j. Knowler, WC, PH Bennett, RF Hamman, and M Miller. Diabetes incidence and prevalence in Pima Indians: A 19-fold greater incidence than in Rochester, Minnesota. Am J Epidemiol 108:497-505, 1978.

k. Balkau B, H King, P Zimmet, and LR Raper. Factors associated with the development of diabetes in the Micronesian population of Nauru. Am J Epidemiol. In press, 1985.

with age, rates vary according to the age group studied, and standardized age-adjusted rates should be used for interstudy comparisons. However, such comparisons remain problematical because of differences in methods among studies. Studies in which information on diabetes diagnoses was gathered from personal interviews, and mail surveys that rely on the knowledge of the person being questioned, miss all undiagnosed cases and those diagnosed cases where the subject is not aware of the diagnosis. Reliance on physician or hospital records eliminates errors of recall, but still omits diabetics who have not been diagnosed. The diagnostic criteria of the World Health Organization (WHO 1980) and the National Diabetes Data Group (NDDG 1979) are stricter than those used in earlier studies, and many "diabetics" in Table 1 would, by current criteria, have impaired glucose tolerance (IGT). Most studies have not discriminated between insulin-dependent diabetes (IDDM) and NIDDM, but adult age ranges in Table 1 probably include only a minority with IDDM. In Rochester, Minnesota, for example, about 3 percent of those developing diabetes after age 40 actually had IDDM and were excluded from the table (Melton et al. 1983).

For populations with high incidence rates in younger age groups, such as the Pima Indians, age-adjusting to the population ages 40+ years excluded many young people with NIDDM from incidence rate calculations. For Pima Indians, the age/sex-adjusted incidence rate for the entire population was 28.1 per 1,000 person-years, compared to about 41 for ages 40+. In Rochester, Minnesota, where incidence rates were highest in older age groups, the age/sex-adjusted incidence rate for all ages was 0.65 per 1,000 person-years, compared to 1.7 in ages 40+ years. No IDDM has been found among Pima Indians (even among children) (Knowler et al. 1979) or Choctaw Indians (Drevets 1965).

TEMPORAL CHANGES IN NIDDM FREQUENCY

The incidence of diabetes reported in the National Health Survey of 1935-36 and the 1964-81 National Health Interview Surveys (NHIS) of the National Center for Health Statistics increased between 1935-36 and the early 1970s (Tables 2 and 3, Figure 1). Between 1964 and 1973, incidence rates increased about 30 percent in persons ages 25-54 years, 50 percent in ages 55-64, and 66 percent in ages 65 and older. Since 1973, however, rates have remained stable or declined. Changes in laboratory techniques and the frequency with which laboratory tests were performed may account for increases since 1936 in diabetes diagnoses. For example, in the 1960s, automated glucose analysis was introduced, and greater utilization of blood glucose measurement may have allowed increased rates of diagnosis of the "backlog" of persons with undiagnosed diabetes. It is doubtful, however, that more vigorous attempts at diagnosis would explain all of the increase in incidence rates, as virtually half of persons with NIDDM still remain undiagnosed (Harris et al. 1985). The percent of all diabetics represented by incident cases in the NHIS has declined since 1965 because of the relative growth of the prevalent diabetic population (Table 4).

DEMOGRAPHIC RISK FACTORS

Age

Most studies have demonstrated an increased incidence of NIDDM with increasing age. In the NHIS and in Rochester, Minnesota (Figure 2), the incidence of NIDDM

TABLE 2. *Incidence of diabetes in the United States: Number of newly diagnosed cases per 10,000 population per year*

Age (Years) Year:	1935-36[a]	1964[b]	1965	1966	1967	1968	1973	1975	1978	1979-81
Both sexes										
All ages	3.8	17.6	20.3	18.3	22.4	26.4	29.7	27.7	26.7	22.7
Under 45	1.1	6.6	7.8	6.3	8.2	11.3	13.3	11.0	8.3	10.4
Under 25	0.4	2.6	2.2	4.2	2.7	6.8	7.0	4.1	1.4	3.8
25-44	2.1	14.3	18.8	10.6	19.3	20.2	25.0	23.4	19.2	20.2
45-54	7.9	36.1	36.6	29.8	38.9	49.1	43.5	41.6	46.6	43.9
55-64	14.4	43.6	54.8	57.5	57.7	62.2	75.4	76.2	66.1	58.5
65 and over	13.1	54.6	63.0	56.3	75.0	77.1	86.9	82.5	90.7	48.6
65-74	15.2	57.6	66.1	58.5	66.9	67.5	78.4	85.0	134.3	45.7
75 and over	8.0	49.1	57.4	53.9	89.1	93.2	101.4	78.0	12.3	53.5
Males										
All ages		15.0	18.3	16.5	17.9	24.0	21.7	22.9	19.1	21.9
Under 45		6.5	7.4	6.4	5.3	9.4	9.2	7.3	8.8	8.3
Under 25		0.7	3.0	4.3	1.6	5.3	5.4	2.8	-	2.9
25-44		18.0	16.2	10.7	13.0	18.2	16.6	16.2	23.3	16.5
45-54		30.9	31.5	31.3	41.3	49.8	40.1	30.9	18.9	61.9
55-64		38.4	45.4	57.2	57.6	56.2	71.5	83.7	33.2	61.9
65 and over		42.4	64.4	40.3	51.5	78.2	48.9	76.9	85.9	41.2
65-74		49.7	63.6	45.6	51.5	72.3	63.3	78.7	126.1	40.8
75 and over		27.9	62.1	26.4	51.7	85.5	21.0	73.5	-	42.3
Females										
All ages		20.2	22.2	19.8	26.5	28.7	37.2	32.2	33.7	23.4
Under 45		6.7	8.3	6.3	11.0	13.0	17.3	14.6	7.8	12.6
Under 25		4.4	1.4	4.0	3.5	8.3	8.6	5.6	2.9	4.7
25-44		11.0	21.1	10.6	25.0	22.1	32.9	30.2	15.3	23.8
45-54		41.0	41.3	28.3	37.5	47.6	45.9	52.3	72.4	27.1
55-64		48.3	62.4	57.8	56.7	67.6	78.7	69.6	95.5	55.5
65 and over		64.4	62.0	69.8	93.0	76.2	112.9	86.3	94.1	53.7
65-74		64.1	68.2	67.4	79.3	62.1	89.9	89.8	140.5	49.5
75 and over		64.9	53.9	71.2	113.1	98.5	151.0	83.0	19.5	60.1

TABLE REFERENCES

a. Spiegelman, M, and HH Marks. Age and sex variations in the prevalence and onset of diabetes mellitus. Am J Public Health 36:26-33, 1946.

b. (1964-81). Drury, TF, and MI Harris, National Diabetes Data Group, from data of the U.S. National Health Interview Surveys, National Center for Health Statistics.

increased with age for both men and women. In Framingham, Massachusetts, there was a tendency towards increasing rates of glucose intolerance with age, but not after adjustment for other factors that increase with age such as weight and very low density lipoprotein (Table 5). Among Pima Indians, incidence rates increased until age 44 in men and age 54 in women and then declined at older ages (Figure 3). In groups with high incidence rates at young ages, such as the Pima Indians, susceptible individuals may have developed the disease at a relatively early age, leading to a decline in incidence at older ages. It is also possible that older persons may not have experienced

TABLE 3. *Incidence of diabetes in the United States: Number (thousands) of newly diagnosed cases per year*

Age (Years) Year:	1935-36[a]	1964[b]	1965	1966	1967	1968	1973	1975	1978	1979-81
Both sexes										
All ages	50	328	383	348	430	517	612	574	570	498
Under 45	11	87	104	85	111	155	190	158	122	158
Under 25	2	22	19	37	24	62	65	38	13	35
25-44	8	65	85	48	87	93	125	120	109	124
45-54	12	77	79	65	86	111	102	98	107	99
55-64	15	71	91	97	99	110	144	147	135	124
65 and over	12	93	109	99	134	142	176	171	206	117
65-74	10	64	74	66	76	78	100	112	196	70
75 and over	2	29	35	34	58	64	76	59	10	47
Males										
All ages		135	167	152	166	226	215	229	197	232
Under 45		42	48	42	35	63	65	52	64	62
Under 25		3	13	19	7	24	25	13	-	13
25-44		39	35	23	28	40	40	40	64	49
45-54		32	33	33	44	54	45	35	21	67
55-64		30	36	46	47	47	64	76	32	62
65 and over		32	49	31	40	62	41	66	80	41
65-74		25	32	23	26	37	35	45	80	27
75 and over		7	16	7	14	24	6	21	-	14
Females										
All ages		193	216	195	264	291	396	346	373	266
Under 45		45	56	43	76	91	125	106	58	96
Under 25		19	6	18	16	38	40	26	13	21
25-44		26	50	25	59	53	85	80	45	75
45-54		45	46	32	43	56	56	64	86	32
55-64		41	54	51	51	63	80	71	103	62
65 and over		61	60	69	94	80	134	105	126	76
65-74		39	42	42	50	40	65	67	116	43
75 and over		22	19	26	43	40	70	39	10	33

TABLE REFERENCES

a. Spiegelman, M, and HH Marks. Age and sex variations in the prevalence and onset of diabetes mellitus. Am J Public Health 36:26-33, 1946.

b. (1964-81). Drury, TF, and MI Harris, National Diabetes Data Group, from data of the U.S. National Health Interview Surveys, National Center for Health Statistics.

the same environmental conditions as younger generations. This pattern is suggested in national incidence data where persons born later show a higher incidence rate when they attain the same age as those born earlier (Figure 4). Alternatively, the national data may represent an increasing likelihood of diagnosis between 1965 and 1975. The increase in incidence with age may have resulted from more frequent medical care in older age groups and hence a greater chance of diagnostic tests being performed, rather than representing a true increase in incidence with age.

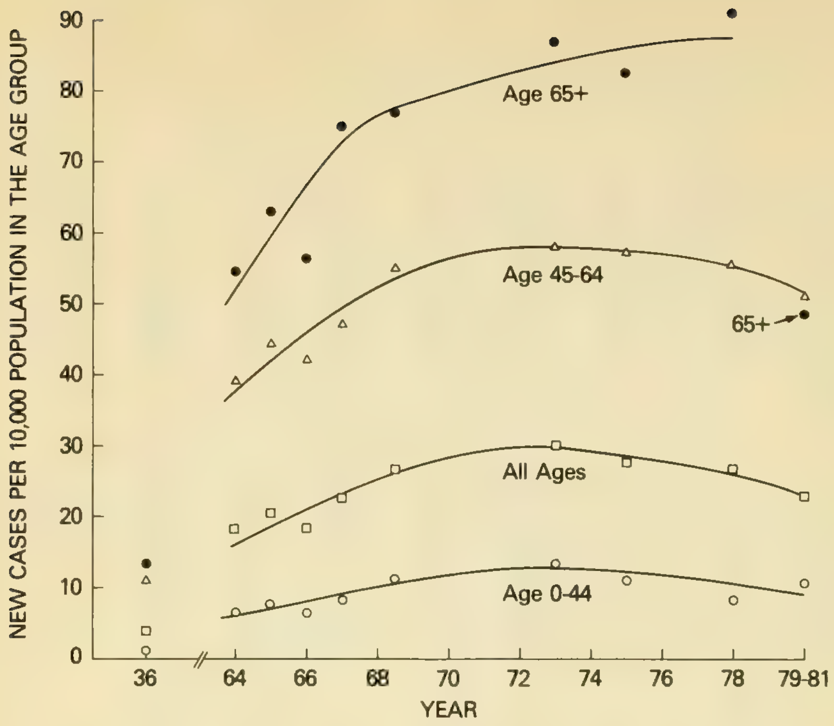

FIGURE 1. *Incidence of diabetes in the United States*

SOURCE: Harris, MI, National Diabetes Data Group, from data of the National Health Interview Surveys, National Center for Health Statistics.

TABLE 4. *Percent of diabetics reporting the initial occurrence of diabetes within the past 12 months, United States, 1935-81*

Age (Years)	1935-36	1965	1973	1975	1979-81
17-44	-	26.6	24.1	18.7	16.9
45-64	-	16.4	13.6	11.3	9.3
65+	-	11.5	11.1	9.7	5.5
All ages	8.9	15.9	14.6	12.0	9.2

SOURCE: Drury, TF, and MI Harris, National Diabetes Data Group, from data of the 1935-36 National Health Survey and the 1965-81 National Health Interview Surveys, National Center for Health Statistics.

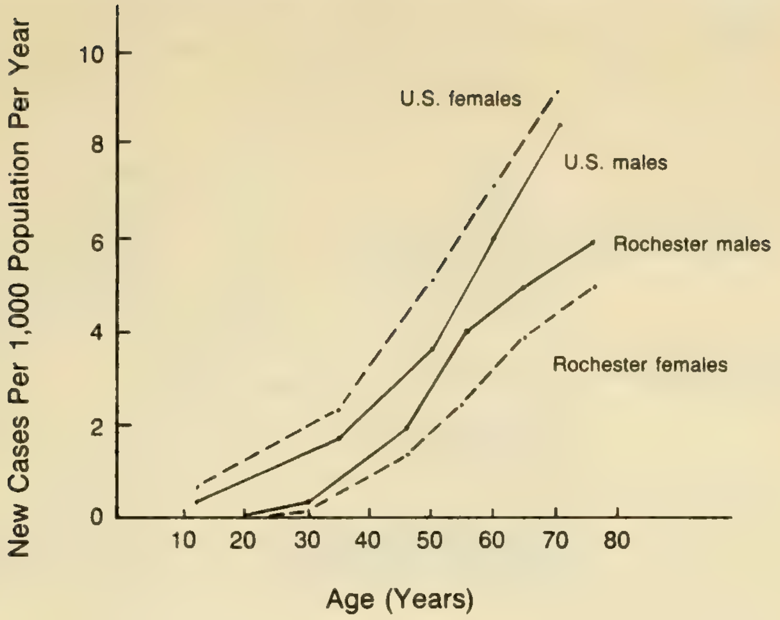

FIGURE 2. *Incidence of diabetes in the 1975-81 National Health Interview Surveys and in Rochester, Minnesota in 1945-70*

SOURCES: U.S.: 1975-81 National Health Interview Surveys, National Center for Health Statistics; Rochester: Palumbo, PJ, et al. Diabetes mellitus: Incidence, prevalence, survivorship and causes of death. Diabetes 25:566-73, 1976.

Sex

There is no clear evidence that gender is a risk factor for development of NIDDM. Although incidence in women was greater than men in the NHIS (Figure 2), this difference may well be due to greater utilization of physicians by women and consequent greater rate of diabetes diagnoses.

Race

Few studies allow adequate comparisons of incidence rates between different racial groups. The highest reported rates occur among Pima Indians and natives of the central Pacific island of Nauru (Table 1). Prevalence studies suggest important differences in the likelihood of developing diabetes among various racial groups. In the United States between 1966 and 1981, the prevalence of diabetes increased 120 percent in blacks but only 60 percent in whites (Harris 1984a). In national data from NHANES II

TABLE 5. *Independent risk factors for glucose intolerance by sex found in multivariate analysis, listed by decreasing level of significance in four studies*

Reference	Study Population	Male	Female
a	Framingham, Massachusetts	Blood glucose Relative weight Very low density lipoproteins Claudication	Relative weight Blood glucose High hemoglobin Very low density lipoproteins
b	Employed Caucasians, northeastern U.S.	Blood glucose Family history of diabetes Age Serum cholesterol Relative weight	
c	Nauru, Micronesia	Age, age^2 2-hour plasma glucose Fasting triglycerides Systolic blood pressure	Age, age^2 2-hour plasma glucose Body mass index 2-hour plasma insulin Glucose-insulin interactions
d	Israeli civil servants	Age Body mass index Peripheral vascular disease/ claudication Serum cholesterol Systolic blood pressure Uric acid Born in Europe - negative risk Education - negative risk	

TABLE REFERENCES

a. Wilson, PW, DL McGee, and WB Kannel. Obesity, very low density lipoproteins, and glucose intolerance over fourteen years: The Framingham Study. Am J Epidemiol 114:697-704, 1981.

b. Dunn, JP, J Ipsen, KO Elsom, and M Ohtani. Risk factors in coronary artery disease, hypertension and diabetes. Am J Med Sci 259:309-22, 1970.

c. Balkau, B, H King, P Zimmet, and LR Raper. Factors associated with the development of diabetes in the Micronesian population of Nauru. Am J Epidemiol, in press, 1985.

d. Medalie, JH, JB Herman, U Goldbourt, and CM Papiers. Variations in incidence of diabetes among 10,000 adult Israeli males and the factors related to their development. In: Levine, R, and R Luft, eds. Advances in Metabolic Disorders. New York: Academic Press, 1978. pp. 93-110.

in 1976-80, blacks had a 50 percent greater prevalence of diabetes than whites (Table 6). Mexican Americans in San Antonio, Texas had a higher prevalence of NIDDM than non-Hispanic Caucasians, and a greater prevalence of obesity among the Mexican Americans could not explain the difference (Table 7).

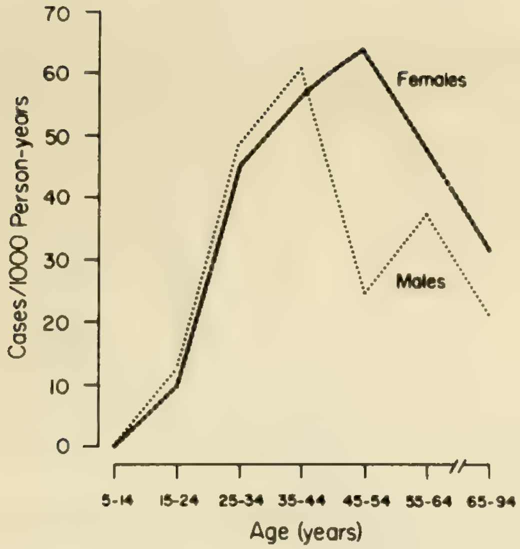

FIGURE 3. *Incidence of diabetes in Pima Indians, 1965-75*

SOURCE: Knowler, WC, PH Bennett, RF Hamman, and M Miller. Diabetes incidence and prevalence in Pima Indians. Am J Epidemiol 108:497-505, 1978.

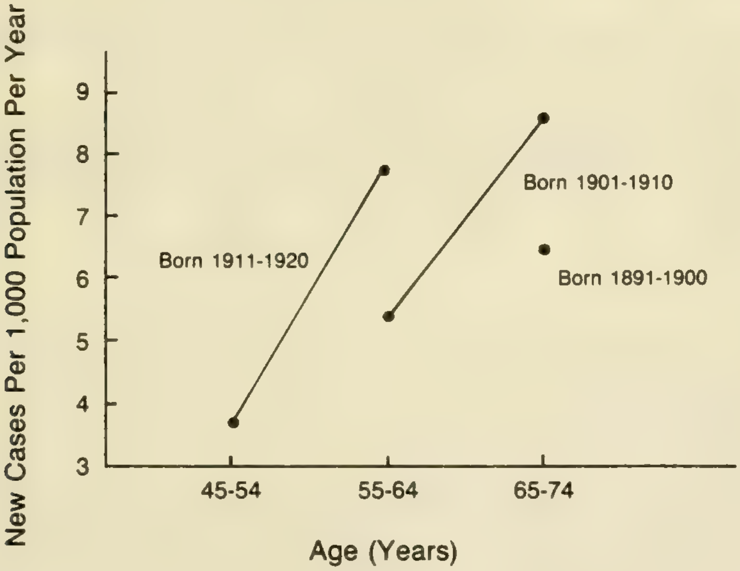

FIGURE 4. *Incidence of diabetes in three birth cohorts*

SOURCE: 1964 and 1975 National Health Interview Surveys, National Center for Health Statistics.

TABLE 6. *Percent of the United States population with diabetes, 1976-80**

	Age (Years)				
	20-74	20-44	45-54	55-64	65-74
White	6.2	1.7	8.2	11.9	16.9
Male	5.3	1.0	7.7	9.1	18.1
Female	7.0	2.2	8.5	14.5	16.1
Black	9.6	3.1	12.9	20.8	25.9
Male	8.5	2.8	11.1	14.4	29.4
Female	10.5	3.5	14.5	25.4	23.1

*Sum of percent of persons with a physician-diagnosed medical history of diabetes and of undiagnosed diabetes using NDDG criteria.

SOURCE: Hadden, WC, and MI Harris. Prevalence of diabetes and impaired glucose tolerance and plasma glucose in the United States population. NCHS Vital and Health Statistics, Series 11, in preparation.

TABLE 7. *Prevalence of NIDDM in Mexican Americans (MA) and Anglo-Americans (AA), by obesity level*

	MA Males		AA Males		MA Females		AA Females	
Obesity Category	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Lean	6/87	6.9	1/55	1.8	2/83	2.4	0/76	0
Average	9/128	7.0	2/55	3.6	9/124	7.3	0/77	0
Obese	24/166	14.5	1/56	1.8	38/334	11.4	6/79	7.6
Overall	39/381	10.2	4/166	2.4	49/541	9.1	6/232	2.6
Ratio MA/AA	4.02				2.41			

SOURCE: Stern, MP, SP Gaskill, HP Hazuda, et al. Does obesity explain excess prevalence of diabetes among Mexican Americans? Diabetologia 24:272-77, 1983.

Diabetes prevalence increases with the degree of native American admixture (Figure 5). Full-heritage Pima Indians had a 1.8-fold greater age/sex-adjusted rate of NIDDM than Pimas with Caucasian admixture (Knowler 1984). The prevalence of diabetes was also greater in full-heritage than in mixed-heritage Cherokee Indians of North Carolina (Stein et al. 1965) and Choctaw Indians of Oklahoma (Drevets 1965).

GENETIC RISK FACTORS

It is generally believed that genetic susceptibility is a prerequisite for development of NIDDM, and the presence of NIDDM in different frequencies among different racial groups and in intermediate frequencies among mixed racial groups all living in the same environment is most easily explained on a genetic basis. Studies of diabetes in families, in twins, and in association with genetic markers have been used to determine genetic risk factors for NIDDM.

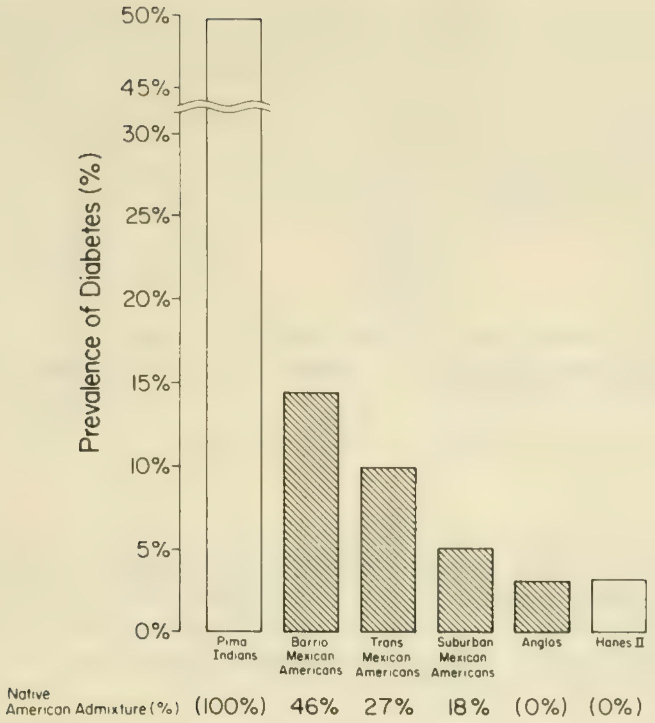

FIGURE 5. *Age-adjusted NIDDM prevalence in six populations with different native American admixture*

SOURCE: Gardner, LI, MP Stern, SM Haffner, SP Gaskill, HP Hazuda, JH Relithford, and CW Eifler. Prevalence of diabetes in Mexican Americans. Diabetes 33:86-92, 1984.

Family Studies

In the 1976 NHIS, 29 percent of persons with a medical history of diabetes reported having a diabetic sibling, compared to only 4 percent of nondiabetic persons (Harris 1984a). In the 1976-80 National Health and Nutrition Examination Survey, among ages 35-74 years, about 35 percent of persons with a medical history of diabetes reported that their mother, father, or both were diabetic. This percent was somewhat lower for persons without a medical history who met NDDG criteria for diabetes (28 percent) or impaired glucose tolerance (27 percent). For those with normal glucose tolerance, 17 percent reported diabetes in one or both of their parents (Harris 1984b). The rate of diabetes in offspring was directly related to parental diabetes status (Table 8). The rate was not different between persons who had only a diabetic mother or only a diabetic father, indicating that the genetic contribution from each parent was equal. In addition, the rate of diabetes in offspring of two diabetic parents was often close to twice that of the rate when only one parent was diabetic, indicating that parental contributions may be additive (Table 8).

TABLE 8. *Percent of offspring who are diabetic, by diabetic status of the parent, United States, 1976-80**

Age of Index Offspring (Years)	Both Parents Diabetic	Only Mother Diabetic	Only Father Diabetic	Neither Diabetic
20-34	5.8	2.1	2.0	0.7
35-44	7.3	3.6	3.2	1.1
45-54	10.5	5.8	8.0	2.9
55-64	25.5	9.6	13.2	3.7
65-74	21.5	11.3	11.7	4.6

*Diabetes defined as respondent reporting in a household interview having a medical history of diabetes in self, siblings, or parents.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Survey, National Center for Health Statistics.

A large family study in Canada quantified the risk of diabetes among first degree relatives of diabetics. Among diabetics ages 20 years and older at onset (presumably mostly NIDDM), diabetes was about two to four times more common in their parents, siblings, and offspring than in a comparison population on Prince Edward Island (Table 9).

TABLE 9. *Percent of relatives with diabetes, and relative age-adjusted prevalence of diabetes in living relatives of diabetic probands compared to relatives in a comparison population on Prince Edward Island, Canada*

	Age at Onset of Proband (Years)					
	Diabetic Male Probands			Diabetic Female Probands		
Relatives	0-19	20-39	>40	0-19	20-39	>40
Fathers (N = 2,883)						
Percent diabetic	2.7	5.1	14.8	3.3	7.6	8.6
Relative prevalence	2	2	4	3	3	3
Mothers (N = 3,378)						
Percent diabetic	0.9	7.7	14.4	2.3	7.4	9.7
Relative prevalence	2	2	3	2	2	2
Brothers (N = 8,830)						
Percent diabetic	2.5	4.0	8.0	2.2	3.2	7.1
Relative prevalence	14	5	4	11	4	3
Sisters (N = 8,992)						
Percent diabetic	1.8	3.4	5.0	3.1	4.2	6.8
Relative prevalence	10	4	2	13	4	2
Sons (N = 5,162)						
Percent diabetic	2.6	1.5	0.7	1.4	0.7	1.4
Relative prevalence	40	13	3	29	6	3
Daughters (N = 5,145)						
Percent diabetic	2.5	0.6	0.9	1.1	1.2	0.7
Relative prevalence	41	7	2	18	9	1

SOURCE: Simpson, N. Diabetes in the families of diabetics. Can Med Assoc J 98:427-32, 1968.

In Pima Indians, diabetes in one or both parents increased the risk of diabetes in offspring although the effect occurred mainly among the most obese offspring (Figure 6). In a family study in Michigan, risk of diabetes was 1.6 times greater if two or more siblings were diabetic than if both parents were diabetic, although diabetes in relatives was not a risk factor once initial glucose levels were accounted for (Beaty et al. 1982). In some families, diabetes occurs at a relatively early age in about 50 percent of offspring, indicating that it might be an autosomal dominant trait (Tattersall 1975). The frequency of this type of diabetes, termed maturity-onset diabetes of the young, and of these families is uncertain.

Although the presence of NIDDM in an individual indicates increased risk for NIDDM in family members, it is difficult to disentangle the roles of genetic and environmental factors shared by family members.

Twin Studies

Comparison of NIDDM rates in monozygotic and dizygotic twins provides a means of evaluation of genetic influences, as environmental differences between monozygotic twins are presumably similar to differences between dizygotic twins. In two studies, monozygotic twins had higher concordance rates for NIDDM than dizygotic twins (Table 10). In another study, among monozygotic twins in whom NIDDM had been diagnosed in at least one twin, 91 percent of the co-twins also had diabetes (Barnett et al. 1981). This concordance rate was considerably higher than among monozygotic twins with IDDM, a disease with well-established genetic markers. Thus, the high concordance rate among monozygotic twins with NIDDM provides strong evidence for heritability of NIDDM.

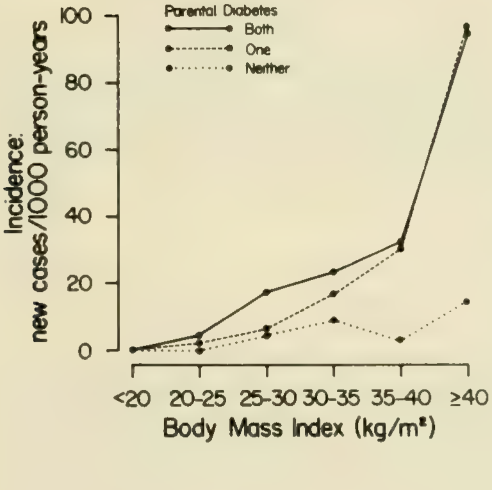

FIGURE 6. *Age-adjusted incidence of diabetes in Pima Indians ages 5-44 years, by Body Mass Index*

SOURCE: Knowler, WC, DJ Pettitt, PJ Savage, and PH Bennett. Diabetes incidence in Pima Indians: Contributions of obesity and parental diabetes. Am J Epidemiol 113:144-56, 1981.

TABLE 10. *Concordance for diabetes in adult twin pairs*

	Joslin Clinic[a]		Denmark[b]	
Zygosity	Number	Percent	Number	Percent
Monozygotic	7/10	70	26/47	55
Dizygotic	1/28	4	20/146	14
Relative risk, mono/di	18		4	

TABLE REFERENCES

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Genetic Markers

No genetic marker linked to NIDDM has been documented, although some associations of genetic markers and NIDDM have been reported. In some populations, modest associations have been found, including HLA-A2 among the Pima Indians (Williams et al. 1981), HLA-A2 in the Xosha of southern Africa (Briggs et al. 1980), HLA-BW56 in Nauruans (Serjeantson et al. 1983), and HLA-BW61 among Fiji Islanders (Serjeantson et al. 1981). The presence of polymorphic DNA insertion sequences near the human insulin gene was 1.8 times more common in subjects with NIDDM than those without NIDDM when data for whites, blacks, and Pima Indians were combined (Rotwein et al. 1983), but no significant association was found among Nauruans (Serjeantson et al. 1983) or among full-heritage Pima Indians (Knowler et al. 1984).

Facial flushing after oral chlorpropamide and ethanol was suggested to be a genetic marker for NIDDM because of higher flushing rates in those with NIDDM (Leslie and Pyke 1978), but this phenomenon has not been consistently replicated. ABO blood type has not been associated with NIDDM except in an Israeli civil servant study, where blood group AB was found to be a risk factor on univariate analysis (Medalie et al. 1978). On multivariate analysis, however, factors such as the country of origin were more strongly predictive of diabetes, implying that ABO blood type was only indirectly associated with diabetes.

METABOLIC RISK FACTORS

Glucose Concentration

Elevated blood or plasma glucose concentration has consistently been the strongest predictor for development of NIDDM, and the higher the glucose value, the greater the likelihood of developing diabetes. This relationship remains in both unifactorial (Bennett et al. 1982, O'Sullivan and Mahan 1965) and multivariate analyses (Beaty et al. 1982, Dunn et al. 1970, Wilson et al. 1981). The incidence of NIDDM among Pima Indians was strongly related to the 2-hour postload plasma glucose concentration prior to developing diabetes (Figure 7).

Although IGT does not irrevocably lead to diabetes (reversion to normal glucose tolerance or persistent IGT also occur), it was the only important predictor of diabetes in four studies. In men in the Paris civil service, blood glucose was the only one of six variables, including weight index and family history, that in multivariate analysis pre-

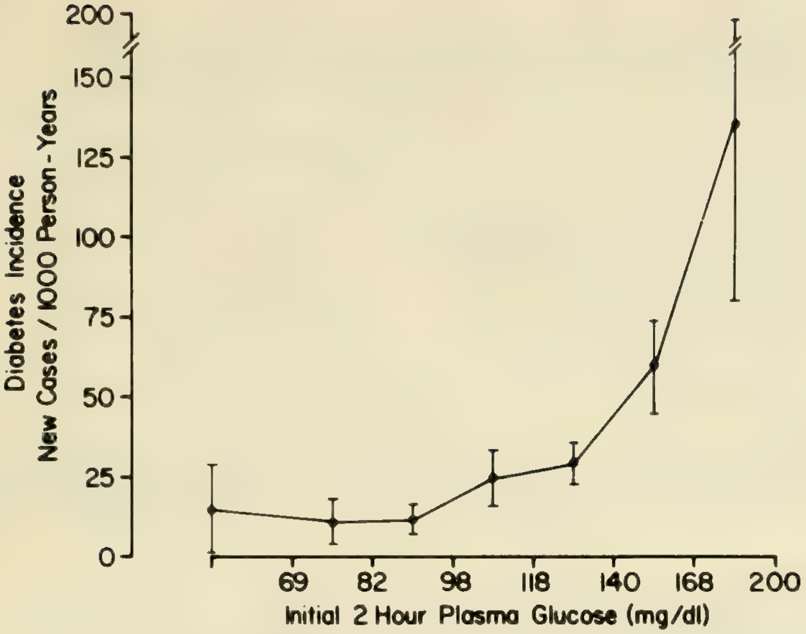

FIGURE 7. *Incidence of diabetes in Pima Indians, by initial 2-hour post-load plasma glucose concentrations, age/sex adjusted to the 1970 United States white population*

SOURCE: Bennett, PH, WC Knowler, DJ Pettitt, MJ Carraher, and B Vasquez. Longitudinal studies of the development of diabetes in Pima Indians. In: Eschwege, E, ed. Advances in Diabetes Epidemiology. Amsterdam: Elsevier Biomedical, 1982. pp. 65-74.

dicted the development of diabetes within 4 years (Papoz et al. 1982). In the Bedford and Whitehall studies in England, the degree of elevation of blood glucose was the only consistent predictor of subsequent NIDDM at 5 and 10 years followup (Jarrett et al. 1982). In a family study in Michigan, the initial glucose tolerance test response was the best predictor for developing diabetes (Beaty et al. 1982).

Three studies have investigated whether pharmacologic and dietary intervention can reduce the rate of development of NIDDM. In a Swedish trial, all groups receiving a prescribed intervention had a lower incidence of diabetes than a group receiving no therapy (Table 11). However, the frequency of examination was higher in the treatment groups, and this increased surveillance may have had a benefit compared to no action. In contrast to the Swedish study, treatment of Bedford, England IGT subjects with tolbutamide, diet, or both for 10 years did not reduce the rate of development of diabetes compared to those treated with no therapy (Keen et al. 1982), and in the Whitehall Study of English civil servants, neither dietary restriction nor treatment with phenformin affected the 10-year cumulative incidence of diabetes (Jarrett et al. 1982).

TABLE 11. *Development of diabetes during 10 years among Swedish persons with impaired glucose tolerance, by treatment*

Treatment Group	Number	Percent
Diet plus continued tolbutamide	0/23	0
Diet plus discontinued tolbutamide	5/26	19
Diet plus continued placebo	4/26	15
Diet plus discontinued placebo	2/22	9
Diet alone	7/50	14
No therapy	17/59	29
Normal glucose tolerance	0/52	0

SOURCE: Sartor, G, B Scherten, S Carlstrom, A Melander, A Norden, and G Persson. Ten-year follow-up of subjects with impaired glucose tolerance. Diabetes 29:41-49, 1980.

Insulin Concentration

In Japanese subjects, diminished insulin response following oral glucose was an independent predictor of development of diabetes over 5-12 years regardless of initial postload glucose concentration (Kadowaki et al. 1984). In Bedford, England deterioration to diabetes among those with IGT was not significantly related to changes in insulin concentration after the effect of glucose concentration was accounted for by logistic regression analysis (Jarrett et al. 1982). Among Pima Indians, insulin concentrations increased with increasing fasting plasma glucose up to 140 mg/dl and 2-hour postload plasma glucose up to 200 mg/dl; above these, there was a decrease in insulin concentration, suggesting that inadequate insulin secretion contributed to the transition from IGT to NIDDM (Bennet et al. 1982). It has not been shown, however, that either insulin resistance or diminished insulin secretion are causes of NIDDM.

Obesity

Obesity is a strong risk factor for NIDDM. Among 13,000 predominantly Caucasian male executives in the northeastern United States, increased relative weight was an independent predictor of diabetes (Dunn et al. 1970), as it was in Framingham, Massachusetts (Wilson 1981). A high correlation was found between mean weight of a country's population and prevalence of diabetes in that country (West and Kalbfleisch 1971). In Oslo, Norway, there was a positive relationship between weight relative to height and 10-year diabetes incidence in 40- to 49-year-old males (Figure 8). Body mass index, another measure of obesity, was a risk factor for NIDDM in Pima Indians, although it was much more predictive of diabetes when at least one parent had diabetes (Figure 6). Similarly, in Oxford, Massachusetts obesity was predictive for development of diabetes only when family history was positive (O'Sullivan 1969).

The distribution of body fat may also determine the risk of development of NIDDM. In a nationwide study of women in a weight reduction program, a greater waist-to-hip ratio, indicating a more central distribution of body fat, was positively associated with diabetes prevalence regardless of degree of obesity (Figure 9). Similar findings were reported for men and women in California (Feldman et al. 1969), France (Vague et al. 1979), and among Mexican Americans (Mueller et al. 1984).

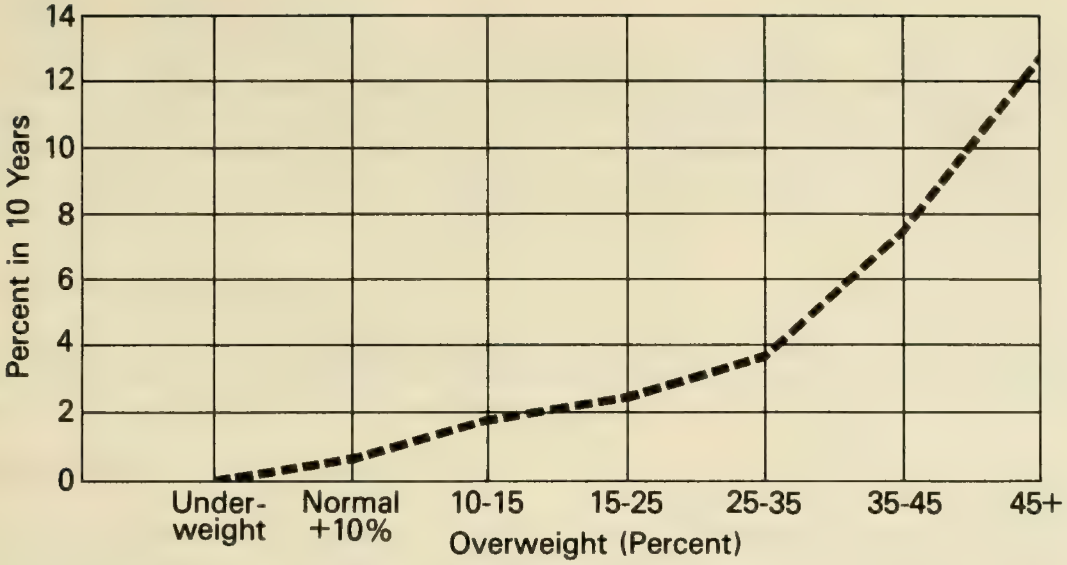

FIGURE 8. *Age-adjusted 10-year incidence of diagnosis of diabetes related to percent overweight at initial examination*

SOURCE: Westlund, K, and JM Nicolaysen. Ten-year mortality and morbidity related to serum cholesterol. Scand J Clin Lab Invest 30:21, 1972.

While weight reduction can decrease plasma glucose concentration in NIDDM patients, it remains to be demonstrated whether weight reduction would reduce the incidence of NIDDM in persons without diabetes.

Plasma Lipids

Hyperlipidemia is associated with both diabetes and obesity, but a relationship independent of obesity between serum cholesterol, very low density lipoproteins (VLDL), and triglyceride levels and development of NIDDM has been found in some incidence studies (Table 5). Serum cholesterol was a significant multivariate risk factor in the 5-year incidence of NIDDM in Israeli males; there was also a positive univariate association with LDL-cholesterol and a negative association with HDL cholesterol that was not significant in multivariate analysis (Medalie et al. 1978). Serum cholesterol was a multivariate predictor for the development of diabetes in men in the northeastern United States (Table 5), but not in Tecumseh, Michigan (Butler et al. 1982) or in middle-aged men in Oslo, Norway (Westlund and Nicolaysen 1972). Elevation of VLDL-cholesterol, but not LDL-cholesterol, was an independent predictor of NIDDM in Framingham, Massachusetts (Table 5). In Nauruan men, but not women, fasting triglycerides showed a weak association with development of NIDDM (Table 5). In the Paris prospective study of male civil servants, diabetes incidence was greater in those whose serum triglyceride concentrations were in the highest tertile as compared to those in the lowest tertile (relative risk = 3.5); however, this association was not apparent after adjustment for fasting blood glucose (Papoz et al. 1982).

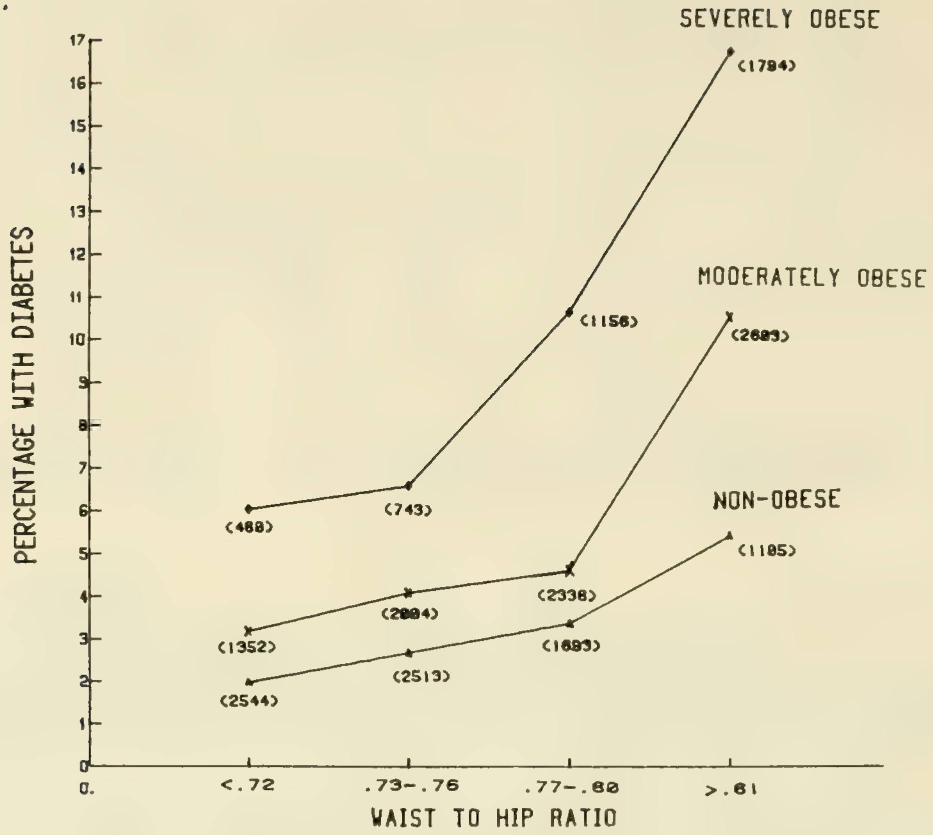

FIGURE 9. *The prevalence of diabetes according to relative weight and body fat distribution in 20,325 women (data from National Survey of Women in TOPS Club, Inc., in 1969)*

SOURCE: Hartz, AJ, DC Rupley, and AA Rimm. The association of girth measurements with disease in 32,856 women. Am J Epidemiol 119:71-80, 1984.

Blood Pressure

Hypertension was more common among DuPont corporation employees who became diabetic than among age, sex, and geographically matched persons who did not become diabetic (Pell and D'Alonzo 1967). This relationship was found across four ranges of obesity, suggesting that blood pressure had an effect independent of obesity. Systolic blood pressure predicted development of NIDDM in United States college men, but only in the higher weight group (Paffenbarger and Wing 1973). In the Whitehall and Bedford surveys in England, blood pressure adjusted for age and obesity was greater in newly diagnosed diabetics (Jarrett et al. 1978), but in followup of those with IGT, blood pressure did not predict subsequent diabetes in either survey (Jarrett et al. 1982, Keen et al. 1982). Among studies utilizing multivariate analyses, only among Israeli male civil servants did blood pressure predict NIDDM when adjustments were made for other associations including age, body mass index, and education (Table 5).

Peripheral Vascular Disease

Peripheral vascular disease is usually considered a complication of diabetes, but a history of intermittent claudication was a significant multivariate risk factor for incidence of diabetes in Framingham, Massachusetts and among Israeli civil servants (Table 5). It is possible that this relationship may not be direct but due to risk factors for both diabetes and peripheral vascular disease that were not examined in these studies.

Drugs and Chemical Agents

Many drugs affect glucose tolerance and may precipitate diabetes or hyperglycemia in susceptible persons (Table 12), but the risks associated with exposure to specific drugs, even those used frequently, are poorly quantified.

Other Metabolic Risk Factors

Increased risks of development of NIDDM have been reported in relation to elevated uric acid (Medalie et al. 1978), high hemoglobin (Wilson et al. 1981), and diminished vital lung capacity (Paffenbarger and Wing 1973), but only in single studies.

ENVIRONMENTAL RISK FACTORS: MIGRATION AND LIFESTYLE

Studies of migrants offer the opportunity to compare the effects of a change in the way of life of emigrants with groups that stayed in their original environment. They also permit comparisons of disease prevalence among different racial groups who come to live in the same location. Changes in lifestyle are often associated with the development of obesity, reduction in caloric expenditure, and changes in diet towards one with lower fiber content and a higher proportion of fat and refined carbohydrates. Migration and rapid changes in lifestyle are associated with the emergence of NIDDM in populations, sometimes in exceptional frequencies. The relative importance of these factors to development of NIDDM may vary among populations and may depend on genetic susceptibility to NIDDM.

Japanese. Diabetes was more common in Japanese migrants to Hawaii (12.3 percent) than in residents of Hiroshima, Japan (6.9 percent) (Kawate et al. 1979). Caloric intake was similar but the migrants were more obese, ate a diet containing a higher proportion of fat and simple carbohydrates, and were more sedentary. In an earlier study, the age-adjusted prevalence of diabetes among Japanese residents of Hawaii was intermediate between that of Caucasians and native Hawaiians (Table 13).

Asian Indians. Asian Indian migrants to many areas of the world have higher prevalence rates of NIDDM than the population residing in India (Taylor and Zimmet 1983). The socioeconomic status of expatriated Indians is frequently higher than those in India, with differences in diet, exercise patterns, and obesity. Migrant Indians also frequently have higher NIDDM rates than the predominant racial group in the host country (Table 13). These differences are not accounted for by recognized environmental factors alone, so Asian Indians may be more genetically susceptible to diabetes than other populations (Taylor and Zimmet 1983).

TABLE 12. *Drugs and chemical agents associated with diabetes and impaired glucose tolerance*

1. Diuretics and Antihypertensive Agents
   - Chlorthalidone (Hygroton, Combipres, Regroton)
   - Clonidine (Catapres, Combipres)
   - Diazoxide (Hyperstat, Proglycem)
   - Furosemide (Lasix)
   - Metalazone
   - Thiazides (several forms, many trade names)
   - Bumetamide
   - Clopamide
   - Clorexolone
   - Ethacrynic acid (Edecrin)

   (Note: Hyperglycemic response to diuretics may be independent of K$^+$ fluctuations)

2. Hormonally Active Agents
   - Adrenocorticotropin (Acthar)
     - Tetracosactrin
   - Glucagon
   - Glucocorticoids (natural and synthetic)
   - Oral contraceptives
   - Somatotropin
   - Thyroid hormones (thyrotoxic doses)
     - Dextrothyroxine (Choloxin)
   - Calcitonin (Calcimar)
   - Medroxyprogesterone (AMEN, Depo-Provera, Provera)
   - Prolactin
   - Megestrol acetate (Megace)

3. Psychoactive Agents
   - Chlorprothixene (Teractan)
   - Haloperidol (Haldol)
   - Lithium carbonate (Eskalith, Lithane, others)
   - Phenothiazines
     - Chlorpromazine (Thorazine)
     - Perphenazine (Trilafon, Etrafon, Triavil)
     - Clopenthixol
   - Tricyclic antidepressants
     - Amitriptyline (Elavil, Endep, Etrafon, Triavil)
     - Desipramine (Norpramin, Pertofrane)
     - Doxepin (Adapin, Sinequan)
     - Imipramine (Presamine, Tofranil, Imavate)
     - Nortriptyline (Aventyl)
   - Marijuana

4. Catecholamines and Other Neurologically Active Agents
   - Diphenylhydantoin (Dilantin)
   - Epinephrine (Adrenalin chloride, Asthma-Meter, Sus-Phrine)
   - Isoproterenol (Isuprel)
   - Levodopa (Bendopa, Dopar, Larodopa, Sinemet)
   - Norepinephrine (Levarterenol, Levophed)
   - Buphenine (Nylidrin)
   - Fenoterol
   - Propranolol (Inderal)

5. Analgesic, Antipyretic, and Anti-inflammatory Agents
   - Indomethacin (Indocin)
   - Acetaminophen (overdose amounts) (Tylenol, Nebs, others)
   - Aspirin (overdose amounts)
   - Morphine

6. Antineoplastic Agents
   - Alloxan
   - L-asparaginase
   - Streptozotocin
   - Cyclophosphamide (Cytoxan)

7. Miscellaneous
   - Isoniazid (INAH, Nydrazid, others)
   - Nicotinic acid (Cerebro-Nicin, Nicobid, others)
   - Carbon disulfide
   - Cimetidine
   - Edetic acid (EDTA)
   - Ethanol
   - Heparin
   - Mannoheptulose
   - Nalidixic acid (NegGram)
   - Nickel chloride
   - Niridazole
   - Pentamidine (Lomidine)
   - Phenolphthalein (Ex-Lax)
   - Rodenticide (Vacor)
   - Thiabendazole

SOURCE: National Diabetes Data Group. Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. Diabetes 28:1039-57, 1979.

TABLE 13. *Diabetes among different populations residing in the same location*

Reference	Location	Population	Percent With Diabetes	Comments
a	Hawaii	Whites	0.7	Rates age-adjusted.
		Chinese	1.5	
		Japanese	2.0	
		Filipino	2.1	
		Hawaiians	4.8	
b,c	Israel	"New" Yemenites	0.06	Twenty years after original study, rate among "new" Yemenites was 11.6%. Rates not age-adjusted, but original age distributions of populations were similar.
		Sephardic	1.0	
		Ashkenazi	2.5	
		"Settled" Yemenites	2.9	
d	Capetown, South Africa	Whites	3.6	Whites and Bantus were the most obese. Dietary history was inconsistently related to rates.
		Bantus	4.2	
		Cape-Coloured (mixed African-White)	10.7	
		Asian Indians	19.1	
e	Trinidad	Blacks	1.4	Age-, occupation-, and residence-specific rates were higher among Indians. Black diabetics were more likely to be obese (53%) than Indian diabetics (39%).
		Asian Indians	2.4	
f	Singapore	Chinese	1.6	Of the diabetics, Malays were most obese, followed by the Chinese, then the Indians.
		Malays	2.4	
		Asian Indians	6.1	
g	Fiji	Fijians (Melanesians)	3.4	Physical activity-specific and residence-specific (rural, urban) age-adjusted rates were higher in the Indians.
		Asian Indians	14.2	

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Jews. In Israel, Yemenite immigrants had a lower prevalence of diabetes (0.06 percent) than earlier settlers in Israel of the same origin and two other new immigrant groups (Table 13). Twenty years later, however, diabetes prevalence in the "new-immigrant" Yemenites had increased to 11.8 percent, suggesting that Yemenites had a predisposition to diabetes which was expressed to a much greater extent in Israel than in their original environment.

Rural to Urban Migration

Migrations within a country permit comparisons of groups of similar ethnic origin. Virtually all migrations are from rural to urban environments and are often accompanied by radical changes in dietary habits, physical activity, and socioeconomic factors. Higher diabetes prevalence rates have frequently been demonstrated among urban residents, indicating an effect of environmental factors on expression of the disease (Table 14). In Puerto Rico, although rural residents had lower rates of diabetes than urban residents, the length of time residing in urban areas did not affect the greater prevalence of diabetes among urban dwellers (Table 14). In the NHIS, there was little difference in diabetes prevalence between urban and rural residents (Table 14).

Modernization

There are populations in which the way of life has changed dramatically over a short time period, with marked changes in the frequency of diabetes, providing strong evidence that environmental determinants may influence expression of the disease. Guam, the chief island of the Marianas, has undergone considerable change to a more Western way of life since the end of World War II. Inhabitants of Guam have a higher prevalence of NIDDM (males 10 percent, females 13 percent) than inhabitants of Rota, a more traditional Marianas island (males 3 percent, females 8 percent), but migrants to California from the Marianas have similar rates (males 10 percent, females 14 percent) to residents of Guam (Reed et al. 1973).

Diabetes was rarely noted among Pima Indians at the turn of the century when their traditional society was intact. Since acquiring a more Western style of living, they have developed the highest known prevalence and incidence rates of diabetes (Table 1). During 1967-77, NIDDM prevalence increased 42 percent (Bennett and Knowler 1980). Obesity also increased during this period. In Nauru within a brief period the population developed one of the highest per capita incomes in the world and the second highest frequency of diabetes (Balkau et al. 1985, Zimmet et al. 1977). Prevalence rates are higher among Polynesians, Micronesians, and Australian Aborigines who adopted a Western style of living than those who retained their traditional ways of living (Zimmet 1979). When diabetic Australian Aborigines returned to their traditional lifestyle as hunter-gatherers for 7 weeks, during which they lost weight, exercised more, and ate a low-fat diet, glucose tolerance markedly improved (O'Dea 1984).

Socioeconomic Status

In some economically developing countries (particularly India), the wealthy are more likely to have diabetes than the poor (Bennett 1983, Gupta et al. 1978), while in the United States the poor have the highest rates of diabetes (Table 15). In Tecumseh, Michigan less formal education was a risk factor for diabetes in men and women ages 20-39 years, but not at older ages (Butler et al. 1982). There are no data on NIDDM incidence by occupation in the United States, although the prevalence of diabetes does not vary by occupation (Drury 1984).

TABLE 14. *Percent of persons with diabetes among rural and urban populations*

Reference	Location and Population	Rural	Urban	Comments
a	Puerto Rico, Hispanic	3.6	-	Rates were for males ages 45-64. Age- and weight-specific rates higher in urban residents.
	Moved from rural <8 years ago	-	8.7	
	Moved from rural 8+ years ago	-	8.4	
	Always urban	-	9.1	
b	India, Asian Indians	1.9	3.0	Age/obesity/income-specific rates higher in urban residents.
c	Western Samoa, Polynesian	3.1	10.1	Age and obesity did not account for difference.
d	Kiribati, Micronesian			Age-standardized rate differences persisted after adjustment for obesity and physical activity.
	Men	3.0	9.1	
	Women	3.3	8.7	
e	Marianas Islands, Micronesian	6.0	12.0	Agricultural population of Rota versus urbanized residents of Guam.
f	Papua, New Guinea, Melanesian	1.0	15.8	Age/obesity-specific rates higher among urban residents.
g	Fiji			Age-adjusted and activity-specific rates higher among urban residents.
	Melanesian	1.6	4.5	
	East Indian	13.1	14.8	
		Urban/Rural Ratio		
h	United States			Age-standardized rates for persons living in or outside of standard metropolitan statistical areas; national health interview data.
	All persons	0.95		
	Males	1.06		
	Females	0.88		
	Whites	0.91		
	Blacks	1.25		

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h. Harris, MI. National Diabetes Data Group. From the 1976 National Health Interview Survey, National Center for Health Statistics.

TABLE 15. *Number of diabetics per 1,000 population, by per capita income quartile, United States, 1976*

Age (Years)	Quartile: I Income: $55-2,165	II $2,166-3,999	III $4,000-6,249	IV $6,250+
25-44				
Whites	13	8	7	6
Nonwhites	23	13	12	11
45-64				
Whites	71	50	37	30
Nonwhites	76	97	82	42
65+				
Whites	84	78	72	58
Nonwhites	110	121	121	96

SOURCE: Harris, MI, National Diabetes Data Group. Data of the 1976 Health Interview Survey, National Center for Health Statistics.

Diet and Exercise

While the balance between caloric intake and expenditure is obviously related to obesity (a major risk factor for NIDDM), the contribution of either to the development of NIDDM is unclear. In the only incidence study that evaluated eating habits among large numbers of people, there was no relationship between caloric intake (or any other aspect of diet) and subsequent development of NIDDM (Medalie et al. 1978, Kahn et al. 1971). In Pima Indians, development of diabetes was related to higher preceding caloric consumption, but the relationship was not statistically significant (Bennett et al. 1984).

There is little information about exercise and risk of NIDDM. Trained athletes have lower insulin responses to glucose infusion compared to nondiabetics (Lohman et al. 1978), and training diminishes insulin resistance while enforced bed rest reduces glucose tolerance by increasing insulin resistance (Bogardus et al. 1984, Lipman et al. 1972). Diabetes prevalence among Fiji Islanders of different races was higher among those with less physical activity (Table 16), but in the United States the percent of persons in various physical activity statuses did not differ by glucose tolerance (Table 17).

TABLE 16. *Age-standardized percent of persons with diabetes, by degree of physical activity and urban/rural status*

	Fijians			Asian Indians		
Physical Activity	Urban	Rural	Both	Urban	Rural	Both
Sedentary/light	5.9	2.3	5.3	14.7	23.9	15.5
Moderate/heavy	2.1	1.0	1.4	8.8	11.2	10.3

SOURCE: Taylor, R, and P Zimmet. Migrant studies in diabetes. In: Mann, JI, K Pyorala, and A Teuscher, eds. Diabetes in Epidemiological Perspective. Edinburgh: Churchill-Livingstone, 1983.

TABLE 17. *Percent distribution of persons in four glucose tolerance statuses, by their degree of physical activity, United States, 1976-80*

Physical Activity and Glucose Tolerance Status*	Age (Years) 20-44	45-54	55-64	65-74
Very active				
Diagnosed diabetes	41.9	37.3	26.8	20.1
Undiagnosed diabetes	54.9	29.7	35.4	34.0
IGT	35.9	35.1	26.1	32.3
Normal	42.7	42.9	39.7	33.0
Moderately active				
Diagnosed diabetes	48.0	41.6	53.2	48.7
Undiagnosed diabetes	41.8	49.5	51.9	55.4
IGT	50.7	52.0	57.0	56.1
Normal	50.7	46.1	51.5	54.9
Inactive				
Diagnosed diabetes	10.1	21.1	20.0	31.2
Undiagnosed diabetes	3.6	20.8	12.8	10.6
IGT	13.4	12.9	16.8	11.6
Normal	6.7	11.0	8.8	12.0

*National Diabetes Data Group criteria applied to the results of 2-hour, 75-gram oral glucose tolerance tests.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

Dietary Components

Dietary components as risks for NIDDM are particularly difficult to evaluate because of unreliability of dietary recall and because the major postulated risks—low intake of starch and fiber, high intake of sucrose and highly processed carbohydrates, and high intake of fat—are often strongly correlated with each other. By 1977, 21 studies reported that sucrose consumption was a risk factor for diabetes and 22 studies reported that it was not (West 1978). In a prospective study of 213 initially nondiabetic Pima Indian women, the incidence of diabetes was no different in women consuming diets with low, medium, or high sucrose content; significantly higher rates of NIDDM occurred in women who ate larger amounts of starch and total carbohydrates, but no difference was found for fat or protein (Bennett et al. 1984). However, no adjustment was made for confounding factors such as obesity, family history, and physical activity. One interpopulation comparison showed a negative correlation between the percent of calories consumed as carbohydrate and the prevalence of hyperglycemia (West 1974). Japanese migrants to Hawaii had about twice the prevalence of NIDDM as Japanese in Hiroshima, and ate approximately twice as much fat, one-third less complex carbohydrate, and almost three times as much simple carbohydrate as those in Hiroshima (Kawate et al. 1979). There is no convincing evidence that dietary composition influences the incidence of diabetes.

RISK FACTORS FOR NIDDM ASSOCIATED WITH PREGNANCY

Gestational Diabetes

In the United States there is little relationship between parity and subsequent NIDDM (O'Sullivan and Gordon 1966). Hyperglycemia first recognized during pregnancy (gestational diabetes, GDM) occurs in about 2 percent of pregnancies and usually diminishes after parturition (O'Sullivan and Mahan 1973). Among Pima Indian women, the degree of hyperglycemia during pregnancy was a risk factor for subsequent NIDDM (Table 18). Similarly, in a Boston study, women with GDM were at greater risk of development of NIDDM than women without GDM, and the weight of the child was also a predictor of subsequent diabetes in mothers who had GDM (Table 19).

TABLE 18. *Diabetes incidence in Pima Indian women 4-8 years after their first pregnancy, by third-trimester 2-hour plasma glucose*

Third-Trimester Glucose (mg/dl)	Percent With Followup Glucose ≥200 mg/dl	Number of Women
<100	4.5	89
100-119	5.3	75
120-139	20.0	40
140-159	16.7	18
160-179	45.5	11

SOURCE: Pettitt, DJ, WC Knowler, HR Baird, and PH Bennett. Gestational diabetes: Infant and maternal complications of pregnancy. Diabetes Care 3:458-64, 1980.

TABLE 19. *16-year incidence of diabetes, by initial category and birth weight of offspring*

Initial Category	Birth Weight (Pounds)	Total Number	Subsequent Diabetes Number	Subsequent Diabetes Percent
Gestational diabetes	<9	268	26	9.7
	≥9	40	11	27.5
Normal glucose tolerance	<9	316	1	0.3
	≥9	12	0	0.0

SOURCE: O'Sullivan, JB, and CM Mahan. Diabetes subsequent to the birth of a large baby: A 16-year prospective study. J Chronic Dis 33:37-45, 1980.

Intrauterine Environment

Among Pima Indians, offspring of mothers who were diabetic during pregnancy had a higher risk of developing NIDDM than offspring of mothers who later developed diabetes (Table 20). This risk persisted regardless of the father's diabetes status and after controlling for the mother's age at diagnosis of diabetes (Pettitt et al. 1984).

TABLE 20. *Percent of offspring with NIDDM for offspring of nondiabetic, prediabetic, and diabetic mothers and fathers among Pima Indians*

Mother's Diabetes Status	Father's Diabetes Status		
	Nondiabetic	Prediabetic	Diabetic
Nondiabetic	.6	1.8	3.6
Prediabetic	1.4	3.9	7.7
Diabetic	9.3	23.0	37.7

SOURCE: Pettitt, DJ, HR Baird, MH Carraher, and WC Knowler. Genetic and intra-uterine environmental effects in transmission of diabetes mellitus. Am J Epidemiol 120:477-83, 1984.

INTERACTIONS OF RISK FACTORS FOR NIDDM

Risk factors for NIDDM probably interact with one another. In Pima Indians the combination of obesity and parental diabetes increased the risk of NIDDM in obese subjects about five-fold over the risk seen in equally obese subjects whose parents did not have diabetes (Figure 9). Similarly, in Oxford, Massachusetts only the combination of obesity and family history of diabetes increased the risk for diabetes. Neither normal weight persons with a family history of diabetes, nor overweight persons without a family history developed more diabetes than expected over a 17-year observation period (O'Sullivan and Mahan 1965). Presumably interactions among other risk factors occur. Given the multitude of risk factors, it is likely that their relative importance varies among populations, which could explain inconsistencies in reports among different populations.

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APPENDIX A. *Percent of persons in diabetes diagnostic categories reporting parental history of diabetes, United States, 1976-80*

Age (Years) and Diagnostic Category*	Both Parents Diabetic	Only Mother Diabetic	Only Father Diabetic	Either Diabetic	Neither Diabetic
35-54					
Medical history of diabetes	3.1	24.8	17.9	45.8	54.2
Undiagnosed diabetes	0.0	10.4	16.6	27.0	73.0
Impaired glucose tolerance	0.0	33.8	4.8	38.6	61.4
Normal glucose tolerance	0.4	11.0	7.5	18.8	81.2
55-74					
Medical history of diabetes	2.6	18.3	8.2	29.1	70.9
Undiagnosed diabetes	0.3	24.5	4.2	29.0	71.1
Impaired glucose tolerance	0.0	13.7	3.7	17.4	82.6
Normal glucose tolerance	0.3	10.3	5.1	15.7	84.3
35-74					
Medical history of diabetes	2.8	20.5	11.5	34.8	65.2
Undiagnosed diabetes	0.2	19.4	8.7	28.3	71.7
Impaired glucose tolerance	0.0	23.1	4.2	27.3	72.7
Normal glucose tolerance	0.4	10.7	6.5	17.6	82.4

*Medical history of diabetes as reported in a household interview; for other three categories, the NDDG diagnostic criteria were applied to the results of a 2-hour 75-gm OGTT.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

APPENDIX B. *Percent of persons who report having a diabetic sibling, by diabetic status of respondent, United States, 1976*

	Age (Years)				
Diabetic Status	0-24	25-44	45-64	65+	All
All persons					
Diabetic	12.1	18.3	32.4	31.3	29.2
Nondiabetic	0.7	3.6	8.8	11.0	4.0
White male					
Diabetic	12.6	13.1	32.6	33.5	
Nondiabetic	0.6	3.2	8.1	10.0	
Black male					
Diabetic	0.0	32.0	28.8	32.4	
Nondiabetic	0.2	4.3	8.4	5.9	
White female					
Diabetic	14.5	17.0	32.8	30.2	
Nondiabetic	0.8	3.6	9.1	12.0	
Black female					
Diabetic	0.0	32.4	33.4	28.7	
Nondiabetic	0.6	5.5	12.8	12.3	

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX C. *Percent of offspring (including siblings of index offspring) who are diabetic, by diabetic status of their parents, United States, 1976*

Age of Index Offspring (Years)	Both Parents Diabetic	Only Mother Diabetic*	Only Father Diabetic*	Neither Diabetic*
0-16	2.92	1.21	1.50	0.20
17-44	8.65	3.82	3.78	0.91
45-74	13.63	7.79	7.45	2.81
75+	33.59	11.73	12.06	3.05

*Includes about 4 percent of spouse pairs where the diabetic status of one or both parents was unknown.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX D. *Percent of persons in certain diabetic and parental diabetic status categories, by age, United States, 1976*

Age (Years) and Diabetic Status	Both Parents Diabetic	Only Mother Diabetic*	Only Father Diabetic*	Neither Diabetic*
0-44				
Nondiabetic	94.4	97.5	98.3	99.6
Diabetic	5.6	2.5	1.7	0.4
45-64				
Nondiabetic	81.7	90.6	91.5	96.5
Diabetic	18.3	9.4	8.5	3.5
65+				
Nondiabetic	70.5	84.0	79.3	93.0
Diabetic	29.5	16.0	20.7	7.0

*Includes about 4 percent of spouse pairs where the diabetic status of one or both parents was unknown.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX E. *Percent of diabetics and nondiabetics, by parental diabetes status, United States, 1976*

Age (Years) and Diabetic Status	Both Parents Diabetic	Only Mother Diabetic*	Only Father Diabetic*	Neither Diabetic*
0-44				
Diabetics	5.09	19.9	11.8	63.2
Nondiabetics	0.39	4.28	3.62	91.7
45-64				
Diabetics	3.78	23.5	9.4	63.3
Nondiabetics	0.69	10.6	4.60	84.1
65+				
Diabetics	1.19	12.4	6.6	79.8
Nondiabetics	0.20	5.47	2.19	92.1
All ages				
Diabetics	3.03	18.7	8.76	69.5
Nondiabetics	0.43	5.64	3.68	90.2

*Includes about 4 percent of spouse pairs where the diabetic status of one or both parents was unknown.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX F. *Diabetes and impaired glucose tolerance among persons with no medical history of diabetes taking drugs that affect glucose metabolism, United States, 1976-80*

Age (Years): Number of Subjects:	20-39 1,374		40-59 1,032		60-74 1,528	
	Number	Percent	Number	Percent	Number	Percent
Diabetes						
Drug taker*	0	0.0	12	1.2	42	2.7
Not drug taker	8	0.6	32	3.1	98	6.4
Impaired glucose tolerance						
Drug taker	0	0.0	11	1.1	37	2.4
Not drug taker	25	1.8	54	5.2	110	7.2
Total						
Drug taker	0	0.0	23	2.2	79	5.2
Not drug taker	33	2.4	86	8.3	208	13.6

*A drug taker is an individual known to be taking an identifiable medication with well-documented propensity to affect glucose metabolism (e.g., thiazide diuretics, glucocorticoids, diazoxide). Excludes 34 individuals who stated that they were taking medication for "blood pressure," "hypertension," or "fluid" but were unable to identify the specific medication.

SOURCE: Siebert, CW, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

CHAPTER V. PREVALENCE OF INSULIN-DEPENDENT DIABETES

Ronald E. LaPorte, Ph.D., and Naoko Tajima, M.D.

SUMMARY

Although there are only limited data concerning the prevalence of insulin-dependent diabetes mellitus (IDDM) in the United States, the results are consistent. In the school-age population, about 1 child in 600 (1.6/1,000) has IDDM. Rates for males and females are approximately equal; rates for whites are greater than for nonwhites. A comparison with other diseases of youth reveals that IDDM is a very prevalent chronic disease among children. Very little is known about the prevalence of IDDM in adults.

METHODOLOGIC PROBLEMS IN ASSESSING IDDM PREVALENCE

There are two major difficulties in determining the prevalence of IDDM: variations in definition of subjects (whether persons are insulin-dependent or merely insulin-using) and incomplete ascertainment of all persons with the disease. The difficulty of definition is particularly evident in older age groups, where a mixture of different types of diabetes plus different treatment philosophies makes it difficult to differentiate between IDDM and insulin-using, noninsulin-dependent diabetes (NIDDM). Most prevalence research has therefore focused on younger age groups (under 20 years), where case definition is believed to be much less of a problem because most cases of diabetes appear to be IDDM.

The types of prevalence research on IDDM fall into five categories that employ different methods to identify cases. The first method is registration of insulin-dependent diabetics through their source of payment for health care. This procedure is typical of studies in Denmark, Finland, and Japan, where patient health care costs are borne by the state. The second method is population surveys such as the United States Health Interview Survey. This has the advantage that all ages are included and it is a national sample. Although it is possible to obtain estimates of IDDM in older age groups, small sample size makes these estimates unreliable. The third method is school surveys. This procedure has been used in Minnesota, Michigan, Pennsylvania, and Tokyo to identify school-age children with diabetes. The fourth method is reporting of cases by

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physicians, hospitals, and other sources to form a registry of prevalent cases. This procedure has been employed in Alabama, North Dakota, and Erie County, New York. The fifth method has been to employ registries of incident cases such as that in Allegheny County, Pennsylvania, to estimate the prevalence of IDDM.

PREVALENCE OF IDDM IN THE UNITED STATES

There has been only limited research in the United States that has specifically examined the prevalence of IDDM. The research that has been completed, however, has produced relatively consistent estimates. Table 1 presents studies that have examined the prevalence of IDDM. Despite major differences in methodology among these studies, the prevalence rate of IDDM in school-age children is relatively consistent at about 1.6 to 1.8 per 1,000, or about one child in 600. This figure represents about 120,000 children with IDDM in the United States. These prevalence data are based only on IDDM developing at a relatively young age. There is a critical need to define the prevalence of IDDM with onset in older age groups.

The Magnitude of the Problem of IDDM

Often the prevalence of IDDM is discussed in relation to NIDDM. However, these are probably different diseases, and a comparison of youth-onset IDDM with older-onset NIDDM may be inappropriate because one is comparing two different chronic diseases: a disease of youth versus a disease of older populations. Examination of the magnitude of the problem of IDDM in the context of other youth-onset diseases is more appropriate. When analyzed, it appears that IDDM may be one of the most prevalent chronic diseases in children (Sultz et al. 1972). IDDM is more prevalent than such well-documented diseases as multiple sclerosis, leukemia, Hodgkin's disease, and muscular dystrophy. Overall, the prevalence of IDDM reveals that it is clearly a major public health problem in youth.

Prevalence by Race and Sex

Table 2 presents studies on the prevalence rates of IDDM by race and sex. The rate for males is similar to that for females. There is a suggestion that the rate is somewhat lower in nonwhites compared to whites. This lower prevalence rate in nonwhites appears to be the result of a somewhat lower incidence (new cases of IDDM) (LaPorte et al. 1981) plus a higher mortality rate in nonwhites (Dorman et al. 1984). The prevalence rates for Allegheny County, Pennsylvania, were determined from the Allegheny County Registry of incident cases. Estimates of prevalence from an incident registry are accurate if in-migration is equal to out-migration, the risk of IDDM development does not change substantially over time, and case fatality rate is low. The prevalence rates for Allegheny County were determined with the assumption that these three criteria were valid.

Prevalence by Grade in School

Table 3 presents data concerning IDDM prevalence by year in school. Prevalence steadily rises so that by the 12th grade approximately 0.25 percent of school children (1 child in 400) has diabetes.

TABLE 1. *Prevalence studies of insulin-dependent diabetes mellitus (IDDM) in the United States, 1961-83*

Reference	Location	Year of Study	Type of Study	Age (Years)	Prevalence Rate (Number/1,000)
a	Erie County, NY	1961	Hospital records	<16	0.61
b	Rochester, MN	1970	Hospital/physician records	5-18 <15	1.21 0.57
c	Michigan (excluding Detroit)	1972-73	School survey	0-18	1.6
d	National Health Interview Survey	1973	Interview	<16	1.3
e	Pennsylvania	1975-76	School survey	5-17	1.71
f	Allegheny County, PA	1976	Estimate from incidence data	5-17	1.73
g	National Health Interview Survey	1976	Interview	<16	1.6
h	Minnesota	1978	School survey	5-17	1.88
i	Kentucky	1979	School survey	5-17	2.10
i	Rhode Island	1980	Random sample	<15	2.50
i	Colorado	1981	School survey	<15	1.7
i	Utah	1981	Random sample	<15	1.20
j	National Health Interview Survey	1979-81	Interview	<20	1.3
k	North Dakota	1983	Outpatient records	<19	1.30

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TABLE 2. *Number of insulin-dependent diabetes mellitus (IDDM) cases per 1,000 persons, by race and sex, United States, 1961-81*

Reference	Study, Date, and Age (Years)	White Males	White Females	Nonwhite Males	Nonwhite Females
a	Erie County, NY, 1961, age 0-16	0.56	0.63	0.40	0.20
b	Allegheny County, PA, 1976, age 5-17	1.80	1.73	1.38	1.49
c	National Health Interview Survey, 1976, age 0-16	2.0	1.4	1.5	1.1
d	Minnesota, 1978, age 5-17	1.89	1.93	--	--
e	National Health Interview Survey, 1979-81, age 0-19	1.4	1.4	--	--

TABLE REFERENCES

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b. LaPorte, RE. As calculated from data of the Allegheny County IDDM Registry, Allegheny County, Pennsylvania.
c. 1976 National Health Interview Survey, National Center for Health Statistics.
d. Kyllo, CJ, and FQ Nutall. Prevalence of diabetes mellitus in school-age children in Minnesota. Diabetes 27:57-60, 1978.
e. 1979-81 National Health Interview Surveys, National Center for Health Statistics.

TABLE 3. *Distribution and prevalence rates of diabetes in school children by grade, Minnesota, 1974-75*

Grade	Total Number of Diabetics	Percent Distribution	Total Population of Children	Number Diabetic Per 1,000
K	40	2.6	57,422	.70
1	48	3.1	52,968	.91
2	64	4.2	52,440	1.22
3	60	3.9	53,852	1.11
4	78	5.1	57,327	1.36
5	117	7.6	61,167	1.91
6	128	8.3	64,914	1.97
7	124	8.1	69,728	1.78
8	163	10.6	70,703	2.30
9	172	11.2	71,936	2.39
10	191	12.5	72,566	2.63
11	188	12.3	67,302	2.79
12	160	10.4	63,903	2.50
Total	1,533	100.0	816,228	1.88

SOURCE: Kyllo, CJ, and FQ Nuttall. Prevalence of diabetes mellitus in school-age children in Minnesota. Diabetes 27:58, 1978.

Prevalence by Age and Sex

Table 4 presents the percent distribution of diabetic children identified in two school surveys. The distributions in the two surveys were similar, although there may have been fewer children in the older ages in Michigan. The distribution was very similar for males and females.

TABLE 4. *Percent distribution of children reported to be diabetic by age and sex, Pennsylvania, 1976, and Michigan, 1972*

Age (Years)	Both Sexes		Male		Female	
	Pennsylvania	Michigan*	Pennsylvania	Michigan*	Pennsylvania	Michigan*
0-5	2.1	2.4	1.8	2.5	2.4	2.7
6	3.0	3.5	3.3	3.3	2.6	4.1
7	3.6	3.5	3.4	3.6	3.8	4.0
8	4.4	5.1	4.2	6.1	4.7	4.9
9	4.7	5.4	4.6	5.8	4.8	5.8
10	6.2	7.3	6.5	8.7	6.0	7.0
11	7.2	8.2	7.6	8.7	6.8	9.0
12	8.4	9.4	8.4	10.4	8.5	9.8
13	9.5	8.5	8.5	8.0	10.5	10.1
14	10.7	10.5	10.6	10.0	10.8	12.6
15	13.2	10.4	13.1	11.7	13.3	10.5
16	13.4	8.9	12.5	10.2	14.3	8.9
17	11.5	8.0	12.7	8.7	10.3	8.4
18 and 19	1.8	2.3	2.6	2.6	1.0	2.3
Unknown	0.3	6.5	0.2	-	0.3	-

*Excludes Detroit.

SOURCES: Digon, E, and WA Miller. The prevalence of juvenile-onset diabetes in Pennsylvania's schools, 1976. Pennsylvania Department of Health, August 1977. Gorwitz, K, GG Howen, and T Thompson. Prevalence of diabetes in Michigan school-aged children. Diabetes 25:122-27, 1976.

Geographic Differences in Prevalence

Comparison of data from Michigan, Minnesota, and Allegheny County, Pennsylvania, does not suggest major geographic differences in the prevalence of IDDM (Table 1). This can also be seen within Pennsylvania, where for its eight health districts there was little geographic variation in the prevalence rates of IDDM, even though there were large socioeconomic and geographic differences in these areas (Table 5).

TABLE 5. *Prevalence of insulin-dependent diabetes mellitus (IDDM) in Pennsylvania by geographic area (school-age population 5-17), 1976*

Area	Reported Diabetics	Population	Rate/1,000	95% CI/1,000
Eastern	300	179,885	1.67	.19
Northeast	230	117,919	1.95	.25
Central	119	69,721	1.70	.31
Southern	332	217,640	1.53	.16
South-Central	179	100,627	1.78	.26
Northwest	317	177,626	1.78	.20
Southwest	121	397,546	1.81	.13
Southeast*	467	299,234	1.56	.14
Total state*	2,665	560,000	1.71	.06

*Excludes Philadelphia.

SOURCE: Digon, E, and WA Miller. The prevalence of juvenile-onset diabetes in Pennsylvania's schools, 1976. Pennsylvania Department of Health, August 1977.

International Variation in IDDM Prevalence Rates

Although there appear to be only limited geographic differences in the prevalence of IDDM in the United States, there are major geographic differences in prevalence across the world. Table 6 presents some of the studies that examine country differences in the prevalence of IDDM. As seen, there are major differences among school-age children. The United States at 1.6 per 1,000 has one of the highest rates in the world. These differences could result from difference in the incidence of the disease and/or from differences in mortality rate.

TABLE 6. *International studies of prevalence of insulin-dependent diabetes mellitus (IDDM) in children*

Reference	Investigators and Year of Report	Population	Age (Years)	Rate Per 1,000	Method of Ascertainment
a	Guell (1974)	Cuba	0-14	0.13	Registry
b	Tan et al. (1981)	Prince Edward Island, Canada	0-9	0.5	Health department registry
			10-19	2.4	
a	Falconer et al. (1971)	Edinburgh	0-9	0.13	Comprehensive survey for known cases
			10-19	0.93	Diagnosed cases
a	Beardmore and Reid (1966)	North Hampton-shire, England	5-16	0.8	Diagnosed cases
a	Wadsworth and Jarrett (1974)	Britain	11	0.1	Diagnosed cases in a cohort
			17	0.5	
			25	3.4	
a	National Child Development Study (1974)	Britain	7	0.2	Questionnaire
			11	0.5	
			16	1.4	
a	Teuscher (1975)	Canton of Berne, Switzerland	0-19	0.59	Known cases plus urine screening
a	Schliack (1973)	East Germany	0-9	0.2	Diagnosed cases
			10-19	0.8	
			20-29	1.6	
a	Lestradet (1977)	France	0-19	0.3	Registry (insulin-treated only)
a	Fromantin et al. (1971)	Vincennes, France	19-20 (men only)	1.2	History and urine screening in 98,700
a	Rostlapil et al. (1976)	Czechoslovakia	0-15	0.39	Registry
a	Kruger (1965)	Schwerin, East Germany	1-9	0.16	Urine screening in 102,219
			10-19	0.8	
a	Pinelli (1976)	Venice, Italy	0-13	0.26	
a	Silwer (1958)	Kristianstad, Sweden	0-4	0.1	Comprehensive survey for known cases
			5-9	1.3	
			10-19	1.7	

(Continued)

TABLE 6. (Continued)

Reference	Investigators and Year of Report	Population	Age (Years)	Rate Per 1,000	Method of Ascertainment
a	Holmgren et al. (1974)	Vasterbotten County, Sweden	0-15	2.2	Known cases
c	Dahlquist et al. (1982)	Sweden	0-14	1.5	Diagnosed cases
d	Reunanen et al. (1982)	Finland	0-19	2.6	Population
a	Christau et al. (1976)	Denmark	0-29	0.7	Registry
a	Cohen (1970)	Israel	2-16	0.16	Diagnosed cases
		Father born in Asia or Africa	2-16	0.09	
		Father born in Europe, "America," or Israel	2-16	0.24	
a	Hososako and Matsuyama (1966)	Kitakyushu City, Japan	1-15	0.1	Health insurance records
e	Kitigawa et al. (1983)	Tokyo, Japan	0-18	0.06	Central registry
a	Proust and Smithurst (1968)	Australia	20 (males)	3.7	Interview and screening, registration for national service
		Canberra and Toowoomba	0-19	1.0	Screening survey

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APPENDIX A. *Number and rate of diabetes among Pennsylvania school children (excluding Philadelphia), 1975-76*

Type of School	Enrolled Children	Diabetic Children	Number of Diabetics per 1,000 Children
All schools	1,560,200	2,665	1.7
Public	1,405,054	2,391	1.7
Parochial/private	145,913	247	1.7
Special education	9,233	27	2.9

SOURCE: Digon, E, and WA Miller. The prevalence of juvenile-onset diabetes in Pennsylvania's schools, 1976. Pennsylvania Department of Health, August 1977.

APPENDIX B. *Annual trend in the relative frequency of diabetes as the final diagnosis explaining admission in patients, United States, 1970-76*

Year of Discharge	Rate Per 10,000 Pediatric Discharges
1970	30.2
1971	32.0
1972	34.3
1973	35.0
1974	34.6
1975	37.4
1976	37.2

SOURCE: Matteson, AL. Diabetes in the young. PAS Reporter 16:7-20, 1978.

CHAPTER VI. PREVALENCE OF NONINSULIN-DEPENDENT DIABETES AND IMPAIRED GLUCOSE TOLERANCE

Maureen I. Harris, Ph.D., M.P.H.

SUMMARY

Noninsulin-dependent diabetes mellitus (NIDDM) is one of the most common chronic diseases in the United States. About 2.5 percent of the population has been diagnosed by a physician as having diabetes, amounting to 5.8 million persons based on 1984 estimates of the population. Approximately 90-95 percent of these cases are NIDDM. An additional 4 to 5 million persons ages 20-74 years meet the diagnostic criteria for NIDDM but have not yet been diagnosed. The prevalence of diabetes has steadily increased since the first systematic health survey of the United States was conducted in 1935-36, and it can be expected to continue increasing as a result of the diagnosis of approximately 500,000 new cases each year and the declining death rate of diabetics. Between 7 and 18 million persons ages 20-74 years (4.6-11.2 percent of the population) have a less severe condition, impaired glucose tolerance (IGT).

NATIONAL PREVALENCE SURVEYS

Over the past 25 years, diabetes mellitus has been one of the diseases included in the National Health Interview Surveys (NHIS) and Health Examination Surveys conducted by the National Center for Health Statistics. Because these surveys have been based on a statistically selected sample of the United States population, they reflect the national prevalence of diabetes. However, they have several drawbacks, in that they contain no component to medically verify that the surveyed person has diabetes, they do not permit differentiation between insulin-dependent diabetes mellitus (IDDM) and NIDDM, and, with a single exception, they cannot ascertain undiagnosed cases of diabetes. The exception is the Second National Health and Nutrition Examination Survey (NHANES II), conducted in 1976-80, in which oral glucose tolerance tests (OGTTs) were administered to a statistical sample of the United States population.

The format used consistently since the first national survey of 1935-36 is an interview in the household of a random sample of the United States population. The households

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are chosen on the basis of data from the census so as to be representative of the United States by age, sex, race, and geographic location. Approximately 40,000 households comprising 120,000 persons have been interviewed annually in the NHIS (over 2.5 million persons were interviewed in the 1935-36 survey), making this survey the largest source of primary data on the health characteristics of the United States population.

During the interview, a detailed medical history is taken. The presence of diabetes in sample persons is ascertained in several sections of the interview, e.g., through the person's reporting of disabilities due to diabetes or a hospital stay or doctor visit for diabetes, or by responding positively to the direct question, "Do you (or any household member) have diabetes?" In the 1976 NHIS, confirmation of a diagnosis was achieved by asking the person, "Did a doctor tell you that you have diabetes?" and 99 percent of persons responded "yes" to this followup question. In 1962, a study was performed to examine the accuracy of reporting a diagnosis of diabetes in an interview setting, and it was found that about 15 percent of diabetics failed to tell the interviewer that they were diabetic; there was only about a 1 percent overreporting of this disease (Madow 1973). The NHIS questionnaire does not ascertain the criteria the physician used for diagnosis of diabetes, and indeed diagnostic criteria have changed substantially over the past 50 years (see below). In addition, the medical history does not generally contain sufficient data to permit accurate differentiation between IDDM and NIDDM. However, in the 1976 NHIS and NHANES II, data were collected that allow an estimate to be made of the number of diabetics of each type. In those surveys, approximately 5 percent of diabetic respondents appeared to be of the insulin-dependent type since their age at onset was below 30 years of age, they reported continuous use of insulin since diagnosis, and their weight was no more than 20 percent above ideal body weight. The prevalence rates of NIDDM, assuming the remaining 95 percent had this type of diabetes, are shown in Table 1. For all ages, 2.35 percent of the population, or about 1 in every 43 persons, had been diagnosed as having NIDDM.

NHANES II, in addition to the medical history component, contained an examination component in which 75-gram OGTTs were administered in the morning to about 3,700 persons who had fasted overnight for 10 to 16 hours. For those persons with no medical history of diabetes, the diagnostic criteria recommended by the National Diabetes Data Group were applied to the results of their OGTT to estimate the prevalence of undiagnosed diabetes in the United States (Table 1). It is believed that IDDM is a disease with such classic onset and obvious symptoms that virtually no cases are undiagnosed. Consequently, no cases represented in Table 1 are considered to be IDDM. For ages 20-74 years, 3.2 percent of the population were estimated to have undiagnosed NIDDM, representing 4.3 million persons in 1978 at the midpoint of the survey. This rate of undiagnosed NIDDM is about equal to the rate of diagnosed NIDDM in the same age group and indicates that diabetes may be twice as prevalent in the United States as the rates found in the NHIS.

The prevalence rates of diagnosed and undiagnosed NIDDM rise with age, are higher for males than females in some age groups, but are lower for males than females in other age groups. The rate in blacks appears to be consistently higher than whites in all adult age groups. The reasons for these race and sex differences have not been fully investigated, but they could be due to differential rates of diagnosis, to differential rates of survival, or to actual biologic differences in diabetes among the race/sex groups.

TABLE 1. *Number of noninsulin-dependent diabetics per 1,000 population, United States, 1979-81 and 1976-80*

		Whites		Blacks	
Age (Years)	All	Male	Female	Male	Female
Diagnosed NIDDM - 1979-81*					
All	23.5	20.8	24.3	24.1	36.3
0-24	0.4	0.3	0.4	0.2	0.3
25-44	7.8	5.9	8.3	13.0	14.8
45-54	41.9	35.3	38.1	86.1	81.4
55-64	66.7	66.0	57.5	87.4	138.7
65-74	85.9	85.1	79.1	100.1	146.2
75+	87.6	77.9	88.0	71.1	164.7
Undiagnosed NIDDM - 1976-80**					
20-74	32	25	34	40	46
20-44	9	5	8	10	9
45-54	42	32	46	75	70
55-64	62	38	79	52	91
65-74	84	90	73	122	123

*Excludes 35 percent of persons ages 0-44 years and 2 percent ages 45+ years with a medical history of diabetes who appear to be IDDM because of age at onset below 30 years, continuous use of insulin since diagnosis, and weight no more than 20 percent above ideal body weight.

**National Diabetes Data Group criteria applied to the results of 75-gram oral glucose tolerance test.

SOURCE: Harris, MI, from the 1979-81 National Health Interview Survey and 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

TIME TRENDS IN THE PREVALENCE OF DIAGNOSED NIDDM

Tables 2 and 3 present NHIS data on the prevalence of diagnosed diabetes. Figures 1 and 2 illustrate these data. There has been a 10-fold increase in the number of diagnosed cases of diabetes, from 0.5 million diabetics in 1936 (Spiegelman 1946) to 5.4 million in 1979-81. The rate of diagnosed diabetes increased from 0.4 to 2.5 percent, and, at present, virtually 1 in every 40 Americans has been told by a doctor that he or she has diabetes. As discussed above, it is estimated that currently about 95 percent of these diabetics are NIDDM, but it is unknown what percent were NIDDM in earlier surveys.

A variety of reasons could be invoked to explain this upward trend in the prevalence and rate of diagnosed diabetes (Harris 1982). Among these are social or technological factors such as changes in the diagnostic criteria for diabetes, medical recognition of diabetes at earlier stages in its natural history, and increased surveillance for the disease in the nondiabetic population. Changes due to biological factors include increases in incidence (new cases) of diabetes, in the number of persons at risk for this disease (particularly persons of older ages), and increased longevity of diabetics.

Incidence has increased about five-fold in the past 45 years. In 1935-36, the incidence was 5 per 10,000 population; in 1964, the next time that incidence was ascertained, the rate was 17.6 per 10,000. Incidence continued to rise until about 1973 (29.7 per 10,000), coinciding with the steep rise in prevalence, but has declined to 22.7 per 10,000 in 1979-81.

TABLE 2. *Number of persons with diagnosed diabetes per 1,000 population, United States, 1935-81*

Sex and Age (Years)	1935-36	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1973	1975	1976	1978	1979-81
Both sexes																	
All	3.7	9.3	8.7	9.1	10.5	10.6	11.5	12.4	12.7	14.5	16.1	16.2	20.4	22.9	23.6	23.7	24.7
Under 45	1.0	2.3	2.2	2.4	2.5	2.3	2.8	3.3	3.1	3.8	4.2	4.1	5.5	5.9	6.0	6.4	5.9
Under 25	0.5	0.8	0.9	0.8	1.3	1.0	1.3	1.3	1.3	1.6	1.9	2.0	2.2	2.2	2.9	2.3	1.8
25-44	1.8	4.6	4.2	5.2	4.8	4.8	5.5	7.0	6.5	8.0	8.9	8.5	11.6	12.3	13.1	12.9	12.0
45-54	6.6	12.4	12.4	13.8	16.5	14.2	16.7	19.1	18.7	20.0	26.2	27.9	33.2	38.0	40.8	35.1	42.8
55-64	14.3	29.3	27.6	27.3	35.4	35.2	37.0	35.8	38.0	43.7	44.3	41.9	54.2	65.0	59.9	72.3	68.1
65+	18.4	43.3	37.7	39.1	42.2	47.3	47.6	52.1	54.2	62.1	66.1	67.1	78.5	83.0	85.3	80.8	88.4
65-74	19.9	44.9	40.9	41.4	43.4	46.4	47.5	52.6	55.7	64.4	68.9	67.8	77.4	81.7	89.9	81.8	87.7
75+	14.6	39.9	31.5	34.8	40.1	49.0	47.9	51.2	51.5	57.9	61.3	65.8	80.4	85.2	77.3	78.6	89.4
Males																	
All	2.8	8.2	7.8	8.4	10.0	9.4	10.5	10.7	10.9	12.9	13.7	14.2	16.3	20.1	21.1	20.0	22.2
Under 45	0.9	2.7	2.3	2.4	2.5	2.0	2.9	2.8	3.0	3.7	3.3	3.9	4.2	5.1	5.3	5.9	4.9
Under 25	0.5	1.0	1.2	0.8	1.1	1.0	1.2	1.0	1.3	1.5	1.4	1.7	1.7	1.9	2.7	2.1	1.6
25-44	1.5	5.5	4.3	5.1	4.9	4.0	6.0	6.3	6.4	8.2	7.2	8.4	9.1	10.9	9.9	12.1	10.1
45-54	4.5	11.1	11.3	14.5	17.5	13.6	17.1	18.8	16.2	21.5	25.5	22.7	32.2	34.4	40.1	29.5	41.9
55-64	10.0	25.7	24.5	26.5	36.4	33.8	34.4	30.5	32.9	40.4	43.9	38.0	51.3	64.5	61.4	68.0	69.3
65+	14.6	33.3	33.9	34.2	38.0	41.8	41.3	46.9	48.5	51.2	54.9	65.1	60.3	77.9	82.7	69.2	85.2
65-74	15.1	32.6	36.5	35.4	38.4	43.0	39.3	46.9	48.5	51.6	58.2	63.5	63.3	77.2	85.0	68.1	87.9
75+	13.1	35.2	28.4	31.7	36.6	39.3	45.3	47.0	48.9	50.9	48.4	68.0	54.6	79.2	77.9	70.5	79.3
Females																	
All	4.5	10.5	9.5	9.8	11.0	11.7	12.4	14.1	14.3	16.1	18.3	18.0	24.1	25.4	25.9	27.1	27.0
Under 45	1.2	1.9	2.0	2.5	2.6	2.6	2.7	3.8	3.2	3.8	5.1	4.4	6.8	6.6	8.0	6.8	6.9
Under 25	0.5	0.7	0.8	0.8	1.4	0.9	1.4	1.7	1.4	1.7	2.3	2.2	2.8	2.5	3.1	2.4	2.1
25-44	2.0	3.7	4.1	5.3	4.7	5.5	5.0	7.7	6.6	7.9	10.5	8.5	14.0	13.6	16.2	13.6	13.8
45-54	8.6	13.7	13.5	13.1	15.5	14.8	16.2	19.4	20.8	18.7	26.9	32.7	34.2	41.4	41.4	40.3	43.7
55-64	18.2	32.5	30.5	28.0	34.5	36.5	39.4	40.8	42.6	46.7	44.8	45.3	56.8	65.5	58.4	76.3	66.9
65+	21.5	51.6	40.9	43.2	45.7	51.8	52.7	56.2	58.7	70.4	74.7	67.6	91.3	86.6	87.1	88.9	90.7
65-74	23.8	55.9	44.8	46.5	47.4	49.3	54.5	57.2	61.7	74.9	77.4	71.3	88.2	85.3	93.6	92.2	87.7
75+	14.8	43.9	33.8	37.2	42.7	56.2	49.5	54.3	53.6	62.9	70.5	64.3	96.2	88.8	76.8	83.3	95.3

SOURCE: Compiled by the National Diabetes Data Group from data of the U.S. National Health Interview Surveys, Public Health Service and National Center for Health Statistics.

TABLE 3. *Number (in thousands) of persons with diagnosed diabetes, United States, 1935-81*

Sex and Age (Years)	1935-36	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1973	1975	1976	1978	1979-81
Both sexes																	
All	510	1,575	1,485	1,594	1,867	1,908	2,101	2,313	2,385	2,772	3,091	3,175	4,191	4,780	4,974	5,193	5,429
0-24	29	62	72	64	101	79	108	115	118	144	169	179	208	202	266	229	167
25-44	69	208	190	238	218	216	248	319	296	363	402	390	581	645	707	823	733
45-54	101	244	249	282	342	298	350	407	403	438	579	630	777	894	954	766	966
55-64	149	434	415	417	550	556	592	584	630	737	760	741	1,035	1,272	1,188	1,443	1,439
65-74	124	432	400	411	439	486	525	585	623	726	782	784	988	1,105	1,243	1,324	1,338
75+	38	195	159	182	216	273	278	302	314	365	399	452	602	662	616	609	785
Males																	
All	196	668	651	717	862	820	930	964	996	1,190	1,273	1,343	1,620	2,028	2,149	2,076	2,357
0-24	14	36	44	33	46	41	52	41	57	67	63	77	77	87	125	131	71
25-44	28	120	93	111	107	86	129	137	139	177	155	186	219	275	256	409	300
45-54	36	106	110	144	176	138	175	194	170	227	271	246	361	389	452	269	457
55-64	54	184	177	194	270	255	264	238	261	325	358	318	459	594	575	592	689
65-74	48	147	166	163	179	206	198	236	244	260	294	325	350	453	510	477	583
75+	16	75	62	71	84	93	112	118	126	135	131	191	156	231	231	198	258
Females																	
All	313	907	834	877	1,004	1,089	1,171	1,349	1,389	1,583	1,818	1,832	2,571	2,752	2,825	3,117	3,072
0-24	15	25	29	31	55	37	57	74	61	77	106	103	131	115	141	98	96
25-44	41	88	98	126	111	130	119	182	157	186	247	203	363	370	451	414	434
45-54	66	138	139	137	166	160	175	213	232	211	308	384	417	505	502	497	510
55-64	94	250	238	223	280	301	328	346	369	412	403	423	577	678	613	850	750
65-74	76	286	234	248	259	280	328	348	380	467	488	459	638	653	733	846	756
75+	22	121	97	111	132	180	165	184	189	230	268	261	446	431	384	412	527

SOURCE: Compiled by the National Diabetes Data Group from data of the U.S. National Health Interview Surveys, Public Health Service and National Center for Health Statistics.

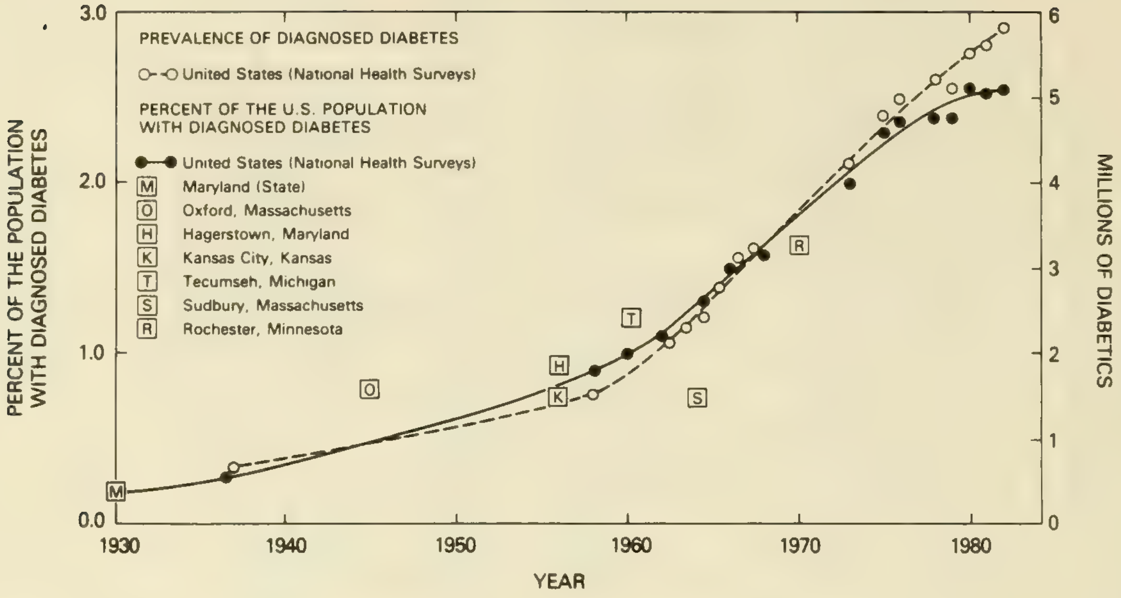

FIGURE 1. *Prevalence of diagnosed diabetes in the United States population, 1930-80*

SOURCE: Harris, MI, National Diabetes Data Group, from data of the National Health Interview Surveys, National Center for Health Statistics and certain community-based surveys.

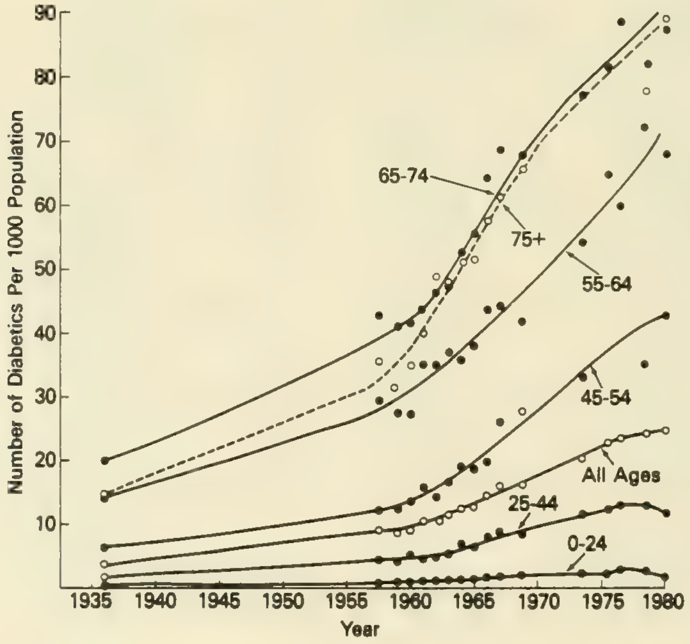

FIGURE 2. *Trends in the rate of diagnosed diabetes in the United States*

SOURCE: Harris, MI, National Diabetes Data Group, from data of the National Health Interview Surveys, National Center for Health Statistics.

Demographic factors have contributed to the increase in the rate of diabetes. One factor is the gradual aging of the United States population. Diabetes rates increase with age, and the proportion of the population that is age 55 years or older has almost doubled in the past 50 years, from 12.3 percent in 1930 to 20.9 percent in 1980. The United States has also experienced disproportionate increases in the number of blacks and Hispanics, two groups with higher diabetes rates than the general United States population.

During the period covered by the national health surveys, there have been changes in the clinical recognition of diabetes that are also likely to have increased the prevalence of diagnosed diabetes. At the beginning of this century, diabetes was diagnosed by the presence of a constellation of symptoms, including polyuria, polydipsia, weight loss, hunger, and dizziness. The biochemical measure generally employed was a determination of urine glucose. Reliance on elevated urine glucose for detection and as a diagnostic criterion for diabetes persisted at least until the mid-1950's. The first comprehensive survey for diabetes, in Oxford, Massachusetts in 1947, required glycosuria as part of the laboratory evidence for diabetes (Wilkerson and Krall 1947). However, milder cases of diabetes that had not proceeded to glycosuria may not have been diagnosed. For example, in the Bedford, England survey of 1962, many people whose urine was glucose-free in screening tests were found to have marked diabetic abnormalities in their OGTT (Keen 1966).

Such findings led the American Diabetes Association to recommend that screening for diabetes involve measurement of blood glucose rather than urine glucose (ADA 1969). The World Health Organization (WHO) also recognized the lack of sensitivity and specificity of urine glucose testing and recommended blood glucose measurement (WHO 1965). The findings, together with more rapid, accurate, and inexpensive methods for analysis of glucose in blood samples, led to the use of elevated blood glucose levels as the hallmark criterion for diagnosis of diabetes. Random, fasting, and postprandial levels were all used. In the 1950's the OGTT became a standard procedure for determination of glucose intolerance, and this test was even more sensitive for the detection of abnormalities of glucose tolerance. For example, a surprising number of abnormal OGTTs were found among a group of persons who had screened negative by postprandial or fasting blood glucose levels (Unger 1957). In the 1965 Health Interview Survey, about 40 percent of diabetics reported having had an OGTT.

Each of these changes in biochemical measures for diabetes is likely to have led to diagnosis of the disease at earlier stages in its natural history, when overt symptoms of diabetes may be absent. The effect of such changes would be to increase the known prevalence of the disease by adding these milder cases to the diagnosed symptomatic cases. In addition, there were extensive efforts to screen for and detect undiagnosed diabetes by communities, by State and local health departments, and by affiliates of the American Diabetes Association. These efforts were aided by new technologies, such as paper strips and the autoanalyzer, that made measurement of blood and urine glucose more accurate, more rapid, and less expensive. These efforts to screen for and detect undiagnosed diabetes in the community, augmented by the new technologies for measurement of urine and blood glucose, coincide with the rapid rise in the prevalence and incidence rates of diabetes between 1960 and 1970.

There are some data that indicate a trend over time toward earlier diagnosis of younger, milder cases of diabetes. Between the 1935-36 survey and the 1968 survey, the highest rate of increase in incidence of diabetes was that of the 0-44 year age group, whose incidence rate increased 12.0-fold during this period, while the rate in older persons increased 5.8-fold (Harris 1983). In a survey for chronic diseases conducted in Baltimore from 1938 to 1943, only 22 percent of diabetics had what would be considered an early diagnosis where there were no symptoms of diabetes; 78 percent were diagnosed after the appearance of symptoms, often quite severe, including diabetic ulcer, diabetic coma, gangrene, and slow-healing sores and infections (Simon 1953). Of all patients with onset of diabetes over age 40 who presented at two diabetes clinics in London during 1953 and 1954, over half were asymptomatic at the time of diagnosis (Reid 1960). In a comprehensive survey for diabetes in Bedford, England in 1962, 70 percent of persons with diabetic OGTTs were asymptomatic (Butterfield 1964). An indicator of the decreasing severity of diagnosed diabetes in the United States is the decreasing rate of use of insulin and oral hypoglycemic drugs. In the 1964-65 Health Interview Survey, 28 percent of diabetics reported using insulin and 50 percent reported using oral drugs; in the 1976 survey these percentages had declined to 22 percent and 41 percent, respectively. If earlier diagnosis of diabetes were occurring, then the proportion of diabetics who are undiagnosed should have declined. This does not appear to be the case, however, as both community and national surveys indicate that there has been about one undiagnosed diabetic for every diagnosed diabetic from 1948 to the present.

Despite the fact that since 1973 new cases are no longer being added to the existing cases of diabetes at an increasing rate, the prevalence of diabetes has continued to grow. The explanation for this growth may be found in the dramatic decline in diabetes mortality since 1970. While the death rate for diabetes as the underlying cause of death rose slightly over the period 1960-69, since 1970 the rate has declined about 19 percent. Although the reason for this decline is still being examined, it appears to be due to a decrease in cardiovascular deaths among diabetics, of whom about 60-70 percent die of cardiovascular diseases (Harris 1980).

COMMUNITY SURVEYS OF DIABETES

A number of community-based surveys for the prevalence of diabetes have been conducted and in some of these there has been medical confirmation of diabetes and documentation of undiagnosed cases. Comparisons among these studies are confounded by the wide range of ascertainment rates, survey methodologies, and diagnostic criteria for diabetes. Genetic, environmental, and personal lifestyle factors associated with onset of NIDDM may also be different in each community, and these may have contributed to the different prevalence rates.

Where the survey formats were similar to those used in the National Health Interview Surveys (essentially, the presence of a medical history of diabetes), the prevalences of diagnosed diabetes found in community surveys tend to match closely the prevalence found in the national data. Table 4 presents a summary of these studies, and some are included in Figure 1.

TABLE 4. *Community-based studies of the prevalence of diabetes and hyperglycemia*

Year	Reference	Population Characteristics/Study Methodology	Diagnostic Criteria	Prevalence	
				Sex and Age (Years)	Rate/1,000 Population
1946	a	Inhabitants of Oxford, Massachusetts; age composition similar to that of the U.S.; 1/3 French Canadian descent, remainder English and Scottish derivation; 70% included in the study (42% of persons ages 75+ years); urine and venous blood were taken 1 1/2 hours after midday or evening meal; glycosurics and persons with blood glucose levels above 160 mg/dl were retested; 100-gm GTT performed on borderline cases.	Newly discovered diabetes: glycosuria and glucose $\geq$170 mg/dl postprandial.	Newly discovered diabetes All	9
			Medical history for previously diagnosed diabetes.	Medical history of diabetes All	11
1954	b	Probability sample of 5,209 residents of Framingham, Massachusetts, ages 30-62 years in 1948.	Physician diagnosis of diabetes (unknown criteria), persons on insulin or oral hypoglycemic agents, or casual blood glucose >160 mg/dl; thus, Framingham diabetics probably include both diabetes and IGT as defined by NDDG criteria.	Males 35-67	34.7
				Females 35-67	25.3
1959-65	c	5,735 residents ages 20+ years in the Tecumseh, Michigan area (total residents $\sim$ 9,800).	Diabetes: physician diagnosis of diabetes and ever used insulin or oral hypoglycemic agents.	Diabetes Males 20+	20
				20-39	5
				40-54	23
				55+	57
				Females 20+	29
				20-39	7
				40-54	31
				55+	89
			Hyperglycemia: 1-hour value >224 mg/dl following 100-gm glucose challenge, or casual blood glucose >124 mg/dl. This approximates the NDDG IGT category.	Hyperglycemia Males 20+	62
				Females 20+	53

TABLE 4. (Continued)

Year	Reference	Population Characteristics/Study Methodology	Diagnostic Criteria	Prevalence: Sex and Age (Years)	Prevalence: Rate/1,000 Population
1964	d	4,626 of all 5,976 residents of Sudbury, Massachusetts, ages 15 years and older; 53 persons (1.1%) had a medical history of diabetes that was confirmed by blood glucose measurements during the study; 18 of 1,350 nonrespondents (1.3%) had a medical history of diabetes, 77% received a limited exam by a physician (45% of persons ages 75+ years); 2-hour afternoon or evening postprandial venous whole blood glucose was measured; persons above 92nd percentile (~110 mg/dl whole blood) were retested postprandially; persons above 98th percentile (~130 mg/dl whole blood) received 100-gm GTT; also did GTT on 5% random sample of the population regardless of initial study results.	Medical history of diabetes: (a) 34 persons on insulin, glycosuria, and postprandial of >200 mg/dl, or "diagnostic" GTT; (b) 7 persons with "undisputed" original diagnosis; (c) 12 persons with postprandial or post-glucose ≥95th percentile.	Confirmed medical history	
				Males ≥15	18
				≥35	28
				Females ≥15	6
				≥35	9
			Newly discovered diabetes: postprandial ≥98th percentile, and post 100-gm glucose as follows: any three or more, or fasting and 3-hour value (whole blood) ≥ fasting (110 mg/dl), 1-hour (170 mg/dl), 2-hour (120 mg/dl), 3-hour (110 mg/dl). Thus, this group of newly diagnosed diabetics contains both diabetes and IGT as defined by NDDG criteria.	Newly diagnosed diabetes + IGT	
				Males ≥15	6
				≥35	9
				Females ≥15	7
				≥35	13
1969	e	2,312 surviving members of the 1948 Framingham cohort of 5,209 adult residents.	Same as Framingham 1954 study.	Males 50+	112
				Females 50+	105
1969	f	290 volunteers of a random sample of 300 men in Tecumseh, Michigan originally studied in 1959.	Use of insulin or oral agents, or 75-gm GTT values as follows: 1-hour >175 mg/dl, 1 1/2-hour >155 mg/dl, 2-hour >135 mg/dl, which approximates the NDDG IGT criteria.	Males 30-39	33
				40-49	108
				50-59	134
				60-69	169
1970	g	All (52,629) residents of Olmstead County, Minnesota, who used any source of medical care; 99% Caucasian; ascertainment of diabetes through review of medical records from all sources of medical care available to the population.	79% of diabetics met NDDG criteria at time of diagnosis; of these, 80% met FPG criteria and 20% met GTT criteria; hence, this population of diagnosed diabetics is essentially a population of fasting hyperglycemics; 5% of diabetics meeting NDDG criteria were probably IDDM, as their age at diagnosis was less than 30 years and they were placed on insulin at diagnosis.	All males	15
				All females	15
				Males <30	1.9
				≥30	33
				Females <30	1.3
				≥30	33
				Males - age adjusted to 1970 U.S. pop.	20
				Females - age adjusted to 1970 U.S. pop.	15

TABLE 4. (Continued)

Year	Reference	Population Characteristics/Study Methodology	Diagnostic Criteria	Prevalence Sex and Age (Years)	 Rate/1,000 Population
1972-74	h	4,944 ambulatory adults representing 82% of residents ages 30-95 years in Rancho Bernardo, California; predominantly white, middle class, suburban persons; half were retirees; participants came to clinic in the morning after 12-hour fast and fasting plasma glucose was measured; previous medical history of diabetes was inquired about but not confirmed by examining the medical record; GTT was not done.	Previous unknown diabetes was defined as FPG $\geq$140 mg/dl. Since a GTT was not done, the prevalence of unknown diabetics meeting NDDG GTT criteria is unknown. Known diabetes was defined by history as diagnosed by the person's physician.	Medical history of diabetes	
				All	45
				Males 30-49	20
				50-69	72
				70+	75
				Females 30-49	13
				50-69	35
				70+	47
				Previously unknown diabetes (FPG criteria)	
				All	29
				Males 30-49	28
				50-69	57
				70+	32
				Females 30-49	14
				50-69	30
				70+	22
1974-82	i	5,350 persons ages 14-64 in Dayton, Ohio, Seattle, Washington, Fitchburg, Massachusetts, Franklin, Massachusetts, Charleston, South Carolina, and Georgetown, South Carolina (Rand Health Insurance Study); 50% were female, 15% were nonwhite, 3,268 (61%) received a glucose load based on skin surface area (range 47-221 gm glucose) in the afternoon.	Diagnosed diabetes: Physician diagnosis and on insulin or oral agents.	M + F 14-64	11
			Undiagnosed diabetes: 2-hour post-challenge blood glucose >200 mg/dl, no medical history of diabetes.	M + F 14-64	12
1977	j	Sample of adults in rural Ohio; households were selected by simple random sampling; questionnaire was mailed to households with completion by and concerning one adult; sample size = 1,909.	Self-reported diabetes.	Adults	53

TABLE 4. (Continued)

Year	Reference	Population Characteristics/Study Methodology	Diagnostic Criteria	Prevalence Sex and Age (Years)	Prevalence Rate/1,000 Population
1978	j	Sample of adults with residential telephones in Michigan; households to be surveyed were contacted by random digit dialing of a probability sample stratified on four population regions; phone interview with and concerning the first adult to answer the telephone; sample size = 3,289.	Self-reported diabetes.	Adults	40
1978	j	Sample of adults ages 18+ years in Pennsylvania; households were selected by multistage area probability sampling to be representative at the county level; phone interview was conducted with an adult household member; sample size = 1,006.	Self-reported diabetes.	18+	56
1979	j	Sample of the noninstitutionalized population of California; multistage sampling to select households to be surveyed; direct interview of one randomly selected adult in the household; sample size = 8,353.	Self-reported diabetes.	18+	34
1979	k	Sample of adults ages 18-45 in seven counties of Kentucky; direct interview was conducted; sample size = 4,223.	Self-reported diabetes.	18-45	24
1979	j	Sample of adults ages 18+ years in South Carolina; households were selected by simple random sampling; direct interview was conducted with all adults in the household; sample size = 2,000.	Self-reported diabetes.	18+	64
1979-81	l	All physician-diagnosed diabetics of Wadena (151 diabetics of 4,699 residents) and Marshall (191 diabetics of 11,161 residents), Minnesota; medical records were abstracted to ascertain physician diagnosis of diabetes.	Verification that diabetes was present on the medical record; it was stated that the study included only Type II diabetics.	All (Wadena) All (Marshall)	17 15

TABLE 4. (Continued)

Year	Reference	Population Characteristics/Study Methodology	Diagnostic Criteria	Prevalence	
				Sex and Age (Years)	Rate/1,000 Population
1980	1	Sample of households in Broome County, New York; households to be surveyed were selected by stratified random sampling based on socioeconomic stratum; direct interview was conducted with an adult knowledgeable of the health of household members; sample size = 2,443.	Self- or proxy-reported diabetes.	All	37
1980	1	Sample of noninstitutionalized Rhode Island residents; households were selected by disproportionate stratified random sampling to be representative of health planning primary care areas; interviews were conducted by telephone (80%) or directly (20%) with the person most knowledgeable of the health of household members; sample size = 5,628.	Self-reported diabetes.	Adults	32
1981	1	Residents of the State of Utah; random-digit dialed statewide survey of 4,513 private households; respondent volunteered answers to questions on physician-diagnosed diabetics among household members and their age and sex; second-stage questionnaire elicited further information.	Person reporting a physician diagnosis of diabetes; 39 of 314 persons originally classed as diabetic were reclassed as nondiabetic in the second-stage questionnaire.	All All males All females Males 0-44 45-64 65+ Females 0-44 45-64 65+	19 14 22 5 39 76 6 57 112
1981	1	Sample of Colorado adults; households to be surveyed were contacted by random digit dialing of a probability sample of residential telephones stratified by urban/rural location; phone interview was conducted with and concerning randomly selected adults; sample size = 469.	Self-reported diabetes.	18+	21
1981	1	Sample of Maine adults ages 18+ years; households to be surveyed were selected by disproportionate stratified multistage probability sampling (e.g., based on health planning districts); direct interview with adults in the household; sample size = 1,222.	Self-reported diabetes.	18+	79

TABLE 4. (Continued)

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PREVALENCE OF OTHER TYPES OF DIABETES

Glucose intolerance can be caused by conditions and diseases other than diabetes. For some of these the etiologic relationship is well established, as in pancreatic disease, abnormalities of the insulin receptor and of the insulin molecule itself, and destruction of the islets by the rat poison Vacor. There are also a number of metabolic conditions and genetic diseases in which the frequency of glucose intolerance is believed to be higher than expected, implying that there is a causal relationship (NDDG 1979). One study has attempted to determine the percent of diabetes cases that are secondary to other conditions. In the population of Olmstead County, Minnesota, it was estimated that approximately 2.2 percent of all prevalent cases of diagnosed diabetes in 1970, and 2.6 percent of new (incidence) cases over the period 1945-69, might be caused by other conditions (Melton et al. 1983).

IMPAIRED GLUCOSE TOLERANCE

Definition

Impaired glucose tolerance (IGT) is a term defined by the National Diabetes Data Group (1979) and the World Health Organization (1980) to encompass persons whose fasting plasma glucose concentration is less than that required for a diagnosis of diabetes (less than 140 mg/dl) and whose plasma glucose value at 2 hours during a 75-gram oral glucose tolerance test is intermediate between diabetic and nondiabetic (between 140 and 200 mg/dl). In addition, the NDDG requires that the person's plasma glucose value, at some time between zero time and 2 hours after the glucose challenge, equal or exceed 200 mg/dl. Thus, to classify a person as IGT, a glucose tolerance test must be performed. Since IGT is a newly created entity, its clinical significance has been only partially investigated. It appears to be a risk factor for the development of diabetes, but it does not necessarily lead to diabetes. It is not associated with the microvascular complications of diabetes, but may convey higher risk for the macrovascular complications.

The term IGT replaced the older terms "borderline diabetes" and "chemical diabetes" which were considered inappropriate because they invoked social, psychologic, and economic sanctions that were considered unjustified in light of the lack of severity of glucose intolerance in these conditions (NDDG 1979).

Prevalence

The prevalence of IGT was explored in the 1976-80 Health and Nutrition Examination Survey in which glucose tolerance tests were administered to about 3,700 persons ages 20-74 years who did not have a medical history of diabetes. The procedure recommended by the NDDG (75-gram oral glucose ingested in the morning after an overnight fast; fasting, 1-hour, and 2-hour venous blood samples analyzed for plasma glucose concentration) was used. From this survey, IGT appears to be very prevalent in the United States population, as 4.6 percent of persons ages 20-74 met the NDDG plasma glucose criteria for this condition and 11.2 percent met the WHO criteria (fasting and 2-hour glucose values) (Table 5).

TABLE 5. *Percent of persons ages 20-74 years with impaired glucose tolerance, United States, 1976-80**

	Age (Years)				
Race and Sex	20-74	20-44	45-54	55-64	65-74
National Diabetes Data Group Criteria					
All races					
Both sexes	4.6	2.1	7.0	7.4	9.2
Males	4.6	1.2	7.3	9.8	8.9
Females	4.7	2.8	6.7	5.2	9.4
White					
Both sexes	4.6	2.0	6.3	7.7	9.5
Male	4.4	1.0	6.3	10.1	9.0
Female	4.7	2.8	6.2	5.5	9.9
Black					
Both sexes	3.8	1.2	10.7	4.5	3.4
Male	5.9	1.4	18.8	7.0	5.4
Female	2.3	1.1	5.1	3.1	1.9
World Health Organization Criteria					
All races					
Both sexes	11.2	6.4	14.8	15.1	22.8
Males	10.3	4.7	13.1	17.2	22.8
Females	12.0	7.8	16.3	13.4	22.7
White					
Both sexes	10.7	5.6	13.6	15.3	23.0
Males	10.2	4.6	12.6	17.2	22.8
Females	11.1	6.5	14.5	13.7	23.0
Black					
Both sexes	12.7	10.3	17.0	14.4	14.5
Males	11.3	4.7	18.8	18.6	22.6
Females	13.6	14.2	15.8	12.2	8.2

*IGT by NDDG criteria requires the following plasma glucose values: fasting <140 mg/dl, oral glucose tolerance test 2-hour value 140-199 mg/dl, and midtest value ≥200 mg/dl; WHO requires the same fasting and 2-hour values, but does not use the midtest glucose value.

SOURCE: Harris, MI, and WC Hadden, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

PRE-, POTENTIAL, AND BORDERLINE DIABETES

Borderline, pre-, and potential diabetes are three terms that the National Diabetes Data Group has recommended be abandoned because of lack of agreement as to their definitions and because their degree of glucose intolerance did not justify the term "diabetes." Nevertheless, these terms have been widely applied, and almost as many persons have been told by a physician that they have these conditions as have been told they have diabetes (Table 6, Figure 3).

TABLE 6. *Number of persons (thousands) with diagnosed diabetes or other categories of glucose intolerance, United States, 1976**

	Age (Years)				
	All	<17	17-44	45-64	65+
Diabetes	4,986	101	899	2,139	1,778
Borderline diabetes	2,794	63	938	1,204	589
Prediabetes	113	1	60	40	11
Potential diabetes	1,221	103	798	266	55
Total	9,116	269	2,695	3,649	2,503

*Based on persons who, during a household medical history interview, reported that a doctor told them that they had the condition.

SOURCE: Harris, MI, and TF Drury, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

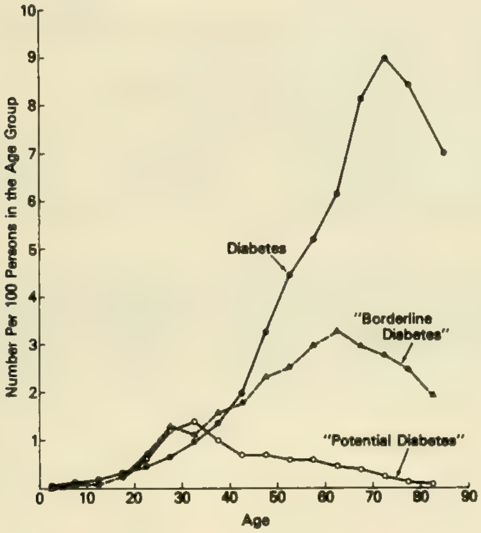

FIGURE 3. *Prevalence of diagnosed diabetes, borderline diabetes, and potential diabetes, United States, 1976*

SOURCE: Harris, MI, and TF Drury, National Diabetes Data Group, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

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APPENDIX A. *Population of the United States, by age, sex, and race, 1980*

Age (Years), Sex, Race	Thousands of Persons
All persons	226,505
Under 25	93,756
25-34	37,075
35-44	25,631
45-54	22,797
55-64	21,700
65-74	15,578
75-84	7,727
85+	2,240
White males	91,670
Under 25	37,886
25-34	15,303
35-44	10,679
45-54	9,556
55-64	9,025
65-74	6,033
75-84	2,573
85+	614
White females	96,671
Under 25	36,477
25-34	15,322
35-44	10,905
45-54	10,056
55-64	10,186
65-74	7,872
75-84	4,421
85+	1,430
Black males	12,516
Under 25	6,615
25-34	1,955
35-44	1,228
45-54	1,019
55-64	851
65-74	565
75-84	227
85+	53
Black females	13,972
Under 25	6,691
25-34	2,254
35-44	1,480
45-54	1,251
55-64	1,056
65-74	774
75-84	359
85+	106
Asian and Pacific Islander	3,500
Males	1,693
Females	1,807
American Indian, Eskimo, Aleut	1,418
Males	701
Females	717
Other	6,757
Males	3,452
Females	3,405
Spanish origin	14,605
Males	7,278
Females	7,327

SOURCE: Bureau of the Census, U.S. Department of Commerce, 1980 Census of the Population, Supplementary Report, May 1981.

APPENDIX B. *Fasting glucose values: mean (mg/dl) and percentiles of fasting venous plasma glucose concentrations in adults ages 20-74 years with no medical history of diabetes, United States, 1976-80*

Race, Sex, and Age (Years)	Mean	Standard Deviation	Standard Error	Percentiles						
				5th	10th	25th	50th	75th	90th	95th
All races										
Both sexes										
20-44	89.5	10.8	0.34	77	79	84	88	94	100	104
45-64	96.8	19.3	0.79	81	84	89	94	101	111	119
65-74	98.1	19.0	0.70	82	84	89	94	102	112	125
Male										
20-44	92.2	9.0	0.33	80	83	87	91	97	102	106
45-64	97.9	16.5	0.74	83	85	90	95	103	112	117
65-74	99.8	20.6	0.99	83	87	91	96	103	115	129
Female										
20-44	87.2	11.8	0.46	75	78	82	86	92	97	102
45-64	95.9	21.7	1.19	80	83	87	93	99	108	120
65-74	96.8	17.9	0.83	81	83	88	94	101	111	121
White										
Both sexes										
20-44	89.3	10.1	0.34	77	80	84	88	94	100	104
45-64	96.8	19.5	0.90	81	84	89	94	101	110	118
65-74	98.1	19.4	0.78	82	84	89	94	102	112	123
Male										
20-44	91.9	8.4	0.31	80	83	87	91	97	102	105
45-64	98.1	16.8	0.78	83	85	90	95	103	112	118
65-74	99.7	20.9	1.01	83	87	91	96	103	115	125
Female										
20-44	87.1	11.0	0.46	76	78	82	86	92	97	101
45-64	95.5	21.9	1.40	80	83	87	93	99	108	118
65-74	96.8	18.4	0.95	81	83	88	94	101	111	121
Black										
Both sexes										
20-44	89.8	16.3	1.28	75	78	83	88	95	103	110
45-64	97.5	19.8	1.35	81	82	89	94	102	111	130
65-74	97.2	16.2	1.80	-	86	88	94	103	112	-
Male										
20-44	94.1	12.2	1.34	-	80	88	92	98	106	-
45-64	95.7	12.8	1.60	-	82	89	96	104	108	-
65-74	98.5	18.9	3.01	-	-	90	96	101		-
Female										
20-44	86.7	18.6	1.87	-	76	80	84	89	97	-
45-64	98.7	24.1	2.31	-	82	89	92	102	128	-
65-74	96.5	16.5	3.17	-	-	88	91	105	-	-

SOURCE: Hadden, WC, and MI Harris. Prevalence of diabetes and impaired glucose tolerance. National Center for Health Statistics, Series 11. In preparation.

APPENDIX C. *One-hour glucose values: mean (mg/dl) and percentiles of venous plasma glucose concentrations 1 hour post 75 grams glucose in adults ages 20-74 years with no medical history of diabetes, United States, 1976-80*

Race, Sex, and Age (Years)	Mean	Standard Deviation	Standard Error	Percentiles						
				5th	10th	25th	50th	75th	90th	95th
All races										
Both sexes										
20-44	130.1	43.5	1.10	71	80	101	125	155	185	208
45-64	160.9	56.5	1.90	86	99	122	155	193	231	255
65-74	171.1	58.4	1.82	94	110	131	164	204	237	275
Male										
20-44	136.0	45.0	1.74	74	85	105	131	162	188	214
45-64	168.6	54.8	2.30	94	108	132	166	199	237	262
65-74	179.0	61.6	2.98	97	119	140	172	207	247	291
Female										
20-44	125.2	42.5	1.51	70	77	96	120	148	176	197
45-64	154.2	58.3	2.77	82	93	115	147	183	223	248
65-74	164.7	56.5	2.47	90	103	125	159	198	230	257
White										
Both sexes										
20-44	129.3	42.1	1.37	71	80	102	125	153	183	203
45-64	161.2	56.8	2.20	86	100	122	154	193	231	254
65-74	171.0	58.3	1.85	92	108	132	165	204	236	266
Male										
20-44	135.6	43.2	1.72	76	85	106	131	161	187	210
45-64	168.6	55.2	2.54	94	109	132	165	198	236	263
65-74	178.3	60.6	2.97	95	119	140	172	207	242	285
Female										
20-44	123.9	41.0	1.72	70	77	96	118	147	175	196
45-64	154.4	58.6	3.19	84	95	115	148	185	222	246
65-74	165.1	57.3	2.61	90	102	125	159	198	231	257
Black										
Both sexes										
20-44	129.7	52.5	3.38	73	81	97	119	155	179	232
45-64	158.9	60.8	4.41	77	89	118	157	189	225	267
65-74	166.6	61.9	8.70	-	113	123	155	193	265	-
Male										
20-44	131.9	54.6	5.78	-	78	98	122	156	199	-
45-64	170.1	56.8	6.86	-	107	138	180	207	238	-
65-74	179.3	71.8	13.57	-		141	160	206	-	-
Female										
20-44	128.0	54.5	5.22	-	81	97	119	149	170	-
45-64	151.5	67.2	8.02	-	79	112	143	171	225	-
65-74	158.4	59.0	11.04	-	-	117	144	180	-	-

SOURCE: Hadden, WC, and MI Harris. Prevalence of diabetes and impaired glucose tolerance. National Center for Health Statistics, Series 11. In preparation.

APPENDIX D. *Two-hour glucose values: mean (mg/dl) and percentiles of venous plasma glucose concentrations 2 hours post 75 grams glucose in adults ages 20-74 years with no medical history of diabetes, United States, 1976-80*

Race, Sex, and Age (Years)	Mean	Standard Deviation	Standard Error	Percentiles						
				5th	10th	25th	50th	75th	90th	95th
All races										
Both sexes										
20-44	100.1	30.6	0.75	63	71	81	96	113	132	152
45-64	119.0	51.7	1.87	66	75	90	109	135	170	209
65-74	133.4	58.5	1.94	72	80	97	122	154	199	240
Male										
20-44	97.4	29.1	1.20	60	67	81	94	111	125	144
45-64	116.0	48.1	2.29	62	70	88	108	133	166	191
65-74	133.9	62.9	3.27	72	79	95	119	154	207	243
Female										
20-44	102.4	32.4	1.12	66	72	82	98	115	136	156
45-64	121.6	55.6	2.62	70	79	91	109	136	177	222
65-74	133.1	56.3	2.33	72	80	99	124	154	196	232
White										
Both sexes										
20-44	99.0	28.7	1.07	63	70	81	96	111	129	146
45-64	118.0	52.3	2.20	64	74	90	107	133	169	205
65-74	132.8	59.3	2.14	71	79	95	121	154	196	234
Male										
20-44	97.1	28.2	1.25	61	67	81	94	111	125	140
45-64	115.3	48.9	2.55	62	69	87	106	132	166	189
65-74	133.2	64.3	3.50	70	78	94	117	153	206	257
Female										
20-44	100.7	29.5	1.43	65	72	82	96	113	133	152
45-64	120.6	56.1	2.94	69	76	91	107	135	175	222
65-74	132.4	56.7	2.61	71	80	97	124	154	195	231
Black										
Both sexes										
20-44	102.6	40.0	2.41	59	71	82	94	116	148	156
45-64	126.1	53.9	4.89	74	81	95	115	147	179	215
65-74	137.4	59.3	7.83	-	96	106	123	149	239	-
Male										
20-44	95.5	26.9	2.25	-	69	83	93	108	126	-
45-64	124.8	44.3	6.31	-	79	101	116	149	167	-
65-74	140.1	60.8	13.36	-	-	106	127	156	-	-
Female										
20-44	107.7	47.7	3.60	-	74	82	99	128	155	-
45-64	126.9	61.4	6.70	-	81	95	113	147	202	-
65-74	135.5	63.8	9.86	-	-	106	114	140	-	-

SOURCE: Hadden, WC, and MI Harris. Prevalence of diabetes and impaired glucose tolerance. National Center for Health Statistics, Series 11. In preparation.

APPENDIX E. *Estimated number of males with diagnosed diabetes, United States, 1980*

State	Age (Years)						
	All	0-24	25-44	45-54	55-64	65-74	75+
Alabama	42,539	1,606	4,754	9,038	10,712	12,116	4,313
Alaska	2,546	139	705	546	665	341	150
Arizona	26,697	826	3,379	3,554	7,104	7,510	4,324
Arkansas	27,755	914	2,703	5,087	6,709	8,836	3,506
California	221,521	6,912	32,283	33,799	62,362	52,561	33,604
Colorado	24,370	878	4,217	3,910	6,541	5,320	3,504
Connecticut	35,279	735	4,578	6,896	11,975	7,954	3,141
Delaware	6,510	238	757	1,510	1,819	1,620	566
District of Columbia	6,918	222	889	1,437	1,813	1,886	671
Florida	138,203	3,370	11,399	23,124	32,737	48,165	19,408
Georgia	54,514	2,296	7,314	12,428	13,835	14,094	4,547
Hawaii	8,851	309	1,349	1,311	2,540	2,141	1,201
Idaho	8,659	306	1,199	1,186	2,294	2,263	1,411
Illinois	122,711	3,854	17,011	23,421	38,999	25,028	14,398
Indiana	57,630	1,908	8,069	11,091	18,039	11,711	6,812
Iowa	33,100	985	4,142	5,699	9,928	7,272	5,074
Kansas	24,072	701	2,855	3,297	6,421	6,123	4,675
Kentucky	40,294	1,532	4,647	8,408	10,132	11,111	4,464
Louisiana	42,151	1,846	5,272	9,220	10,595	11,214	4,004
Maine	12,343	282	1,633	2,290	3,810	3,012	1,316
Maryland	45,137	1,651	5,798	10,731	12,355	10,855	3,747
Massachusetts	62,894	1,375	8,298	11,813	20,556	14,615	6,237
Michigan	96,287	3,243	13,772	18,807	30,746	18,891	10,828
Minnesota	44,153	1,403	6,196	7,829	12,985	9,272	6,468
Mississippi	26,766	1,108	2,905	5,338	6,422	7,954	3,039
Missouri	55,810	1,622	6,954	9,951	16,792	12,645	7,846
Montana	7,682	240	1,021	1,072	2,097	1,971	1,281
Nebraska	15,966	468	1,878	2,161	4,079	4,087	3,293
Nevada	7,611	229	1,163	1,276	2,342	1,800	801
New Hampshire	9,694	230	1,437	1,873	3,024	2,240	890
New Jersey	83,689	1,738	10,602	16,731	28,252	19,045	7,321
New Mexico	11,250	421	1,627	1,729	3,067	2,774	1,632
New York	195,481	4,133	25,216	37,991	63,391	45,465	19,285
North Carolina	62,793	2,413	7,674	14,042	16,489	16,595	5,580
North Dakota	6,670	208	792	856	1,689	1,784	1,341
Ohio	116,471	3,648	15,719	22,614	37,723	23,361	13,406
Oklahoma	30,036	903	3,672	4,214	7,907	7,875	5,465
Oregon	26,209	749	3,595	3,484	7,068	6,869	4,444
Pennsylvania	138,984	2,808	16,354	25,963	46,970	33,770	13,119
Rhode Island	10,896	225	1,311	1,962	3,682	2,626	1,090
South Carolina	31,230	1,347	4,059	6,972	8,326	8,098	2,428
South Dakota	7,245	214	779	934	1,911	1,865	1,542
Tennessee	50,943	1,833	5,941	10,873	12,890	14,196	5,210
Texas	124,323	4,492	18,320	19,330	33,280	30,072	18,829
Utah	10,860	533	1,761	1,629	2,863	2,482	1,592
Vermont	5,274	131	785	994	1,580	1,242	542
Virginia	56,481	2,155	7,486	13,082	15,009	13,991	4,758
Washington	39,438	1,216	5,668	5,688	11,064	9,716	6,086
West Virginia	22,883	774	2,423	4,605	5,959	6,581	2,541
Wisconsin	51,980	1,625	6,883	9,281	15,561	11,372	7,258
Wyoming	3,908	156	683	628	1,030	860	551
Total (thousands)	2,357	71	300	457	689	583	258

SOURCE: National Diabetes Data Group, from data of the 1980 census of the United States population, and age/sex/region-specific rates of diabetes from the 1979-81 National Health Interview Surveys, National Center for Health Statistics.

APPENDIX F. *Estimated number of females with diagnosed diabetes, United States, 1980*

State	Age (Years)						
	All	0-24	25-44	45-54	55-64	65-74	75+
Alabama	64,472	2,156	7,855	12,456	16,355	15,972	9,678
Alaska	2,431	217	782	518	467	309	138
Arizona	29,719	1,369	4,338	4,339	6,692	8,226	4,755
Arkansas	40,137	1,218	4,442	6,938	10,147	10,588	6,804
California	257,327	11,288	41,072	40,177	56,094	62,062	46,634
Colorado	28,244	1,439	5,297	4,576	5,788	6,266	4,878
Connecticut	42,542	715	5,594	6,510	9,416	10,966	9,341
Delaware	9,623	325	1,249	1,979	2,596	2,074	1,400
District of Columbia	11,485	319	1,535	2,070	2,999	2,782	1,780
Florida	199,293	4,485	18,612	31,491	51,811	58,614	34,280
Georgia	83,798	3,042	12,039	16,723	21,050	19,292	11,652
Hawaii	8,758	474	1,670	1,657	2,080	1,734	1,143
Idaho	9,284	507	1,499	1,366	1,993	2,285	1,634
Illinois	162,394	5,145	23,681	21,148	41,596	34,996	35,828
Indiana	75,829	2,557	11,165	10,036	19,372	15,924	16,775
Iowa	44,341	1,316	5,553	5,115	10,467	9,660	12,230
Kansas	28,486	1,140	3,633	3,958	5,769	7,382	6,604
Kentucky	58,889	1,998	7,472	11,132	14,851	14,018	9,418
Louisiana	62,806	2,479	8,575	12,522	15,826	14,486	8,918
Maine	15,158	273	1,925	2,143	3,032	4,074	3,711
Maryland	66,808	2,209	9,570	13,858	17,934	14,088	9,149
Massachusetts	81,574	1,354	10,178	11,316	16,838	21,810	20,078
Michigan	122,577	4,356	19,119	16,953	32,456	24,983	24,710
Minnesota	56,842	1,879	8,328	6,807	13,354	12,031	14,443
Mississippi	40,314	1,481	4,834	7,490	9,904	10,199	6,406
Missouri	75,744	2,167	9,786	9,116	18,317	17,414	18,944
Montana	8,271	395	1,278	1,232	1,759	2,058	1,549
Nebraska	18,668	778	2,416	2,558	3,626	4,788	4,502
Nevada	7,765	377	1,427	1,393	1,876	1,795	897
New Hampshire	11,698	224	1,684	1,696	2,367	3,082	2,645
New Jersey	101,035	1,697	13,272	15,963	22,546	26,665	20,892
New Mexico	12,607	705	2,126	2,094	2,726	3,054	1,902
New York	246,656	4,081	31,877	37,408	52,232	65,903	55,155
North Carolina	95,251	3,138	12,467	19,133	24,982	22,442	13,089
North Dakota	7,094	335	947	995	1,405	1,893	1,519
Ohio	153,577	4,902	22,111	20,635	40,520	32,360	33,049
Oklahoma	35,701	1,469	4,788	5,154	7,237	9,621	7,432
Oregon	29,487	1,244	4,559	4,152	6,294	7,532	5,706
Pennsylvania	171,177	2,744	19,910	25,274	38,517	47,561	37,171
Rhode Island	13,943	222	1,582	1,905	3,011	3,890	3,333
South Carolina	47,632	1,764	6,549	9,554	12,676	11,017	6,072
South Dakota	8,019	355	977	1,102	1,594	2,066	1,925
Tennessee	76,513	2,430	9,728	14,823	19,522	18,385	11,625
Texas	146,133	7,398	23,591	23,367	30,093	35,928	25,756
Utah	12,274	901	2,225	1,907	2,488	2,797	1,956
Vermont	6,433	128	921	900	1,256	1,668	1,560
Virginia	83,099	2,811	11,962	16,996	21,739	18,115	11,476
Washington	44,357	1,978	7,118	6,580	9,623	10,820	8,238
West Virginia	33,721	1,028	3,844	6,343	8,946	8,285	5,275
Wisconsin	66,621	2,167	9,265	8,135	16,313	14,674	16,067
Wyoming	4,150	248	786	681	841	927	667
Total (thousands)	3,072	96	434	510	750	756	527

SOURCE: National Diabetes Data Group, from data of the 1980 census of the United States population, and age/sex/region-specific rates of diabetes from the 1979-81 National Health Interview Surveys, National Center for Health Statistics.

APPENDIX G. *Socioeconomic characteristics of diabetics, United States, 1964-65*

Characteristic	Number (Thousands)			Percent Distribution		
	Both Sexes	Male	Female	Both Sexes	Male	Female
All diabetics	2,300	962	1,337	100.0	100.0	100.0
Age (years)						
Under 25	111	54	57	4.8	5.6	4.3
25-44	281	135	147	12.2	14.0	11.0
45-54	385	161	223	16.7	16.7	16.7
55-64	612	254	358	26.6	26.4	26.8
65-74	610	237	373	26.5	24.6	27.9
75 and over	300	121	179	13.0	12.6	13.4
Race						
White	2,002	873	1,129	87.0	90.7	84.4
Nonwhite	297	89	208	12.9	9.3	15.6
Marital status						
Married	1,493	771	722	64.9	80.1	54.0
Widowed, divorced, separated	619	106	513	26.9	11.0	38.4
Never married	188	86	102	8.2	8.9	7.6
Family income						
Under $3,000	778	261	517	33.8	27.1	38.7
$3,000-$3,999	260	111	148	11.3	11.5	11.1
$4,000-$6,999	463	208	256	20.1	21.6	19.1
$7,000-$9,999	346	158	188	15.0	16.4	14.1
$10,000 and over	299	167	132	13.0	17.4	9.9
Unknown	154	57	97	6.7	5.9	7.3
Education of family head						
Under 5 years	302	105	198	13.1	10.9	14.8
5-8 years	803	327	476	34.9	34.0	35.6
9-12 years	853	382	471	37.1	39.7	35.2
13 years and over	272	130	141	11.8	13.5	10.5
Unknown	70	18	51	3.0	1.9	3.8
Education (years)						
Under 5	334	110	224	14.5	11.4	16.8
5-8	815	332	482	35.4	34.5	36.1
9-12	821	350	471	35.7	36.4	35.2
13 and over	215	117	97	9.3	12.2	7.3
Unknown	116	53	63	5.0	5.5	4.7

SOURCE: National Center for Health Statistics. Characteristics of persons with diabetes, U.S., July 1964-June 1965. Vital and Health Statistics Series 10, Number 40, October 1967. Based on data from the U.S. Health Interview Survey.

APPENDIX H. *Characteristics of diabetics and nondiabetics, United States, 1976*

Characteristic	Age (Years)							
	20+		20-44		45-64		65+	
	Nondiabetics	Diabetics	Nondiabetics	Diabetics	Nondiabetics	Diabetics	Nondiabetics	Diabetics
Number of persons (thousands)	132,962	4,522	71,719	714	41,222	2,031	20,021	1,778
	Percent Distribution							
Race and sex								
White males	42.0	37.1	42.7	33.2	43.0	41.1	37.4	34.2
All other males	5.1	6.1	5.7	5.2	4.7	6.9	3.9	5.6
Black males	4.5	5.4	4.8	4.6	4.2	6.4	3.6	4.7
White females	46.6	47.1	44.5	48.6	46.9	41.8	53.7	52.6
All other females	6.3	9.6	7.1	13.2	5.4	10.1	5.1	7.6
Black females	5.6	9.1	6.2	11.5	4.9	10.0	4.8	7.2
Years of education								
Fewer than 9	17.4	39.5	7.2	15.5	21.4	33.7	45.8	55.7
9-11	14.9	18.0	13.2	18.6	17.6	20.6	15.3	14.7
12	35.9	25.3	40.6	37.7	35.6	29.5	19.8	15.6
13-15	15.7	8.4	20.3	17.8	11.6	7.6	7.8	5.5
16 or more	14.4	6.6	17.5	9.0	12.0	7.4	7.8	4.7
Marital status								
Married	70.6	66.2	70.0	71.8	79.1	76.2	54.9	52.4
Separated	23	3.0	2.8	5.5	2.1	3.8	0.9	1.1
Divorced	5.1	4.5	5.6	8.8	5.4	4.5	2.6	3.2
Widowed	8.2	19.8	0.7	1.0	8.0	9.3	35.4	39.3
Never married	13.9	6.5	20.9	13.4	5.4	6.1	6.2	4.2
Marital status and sex								
Married males	35.4	34.1	33.2	26.8	41.0	40.6	32.0	29.6
Divorced, separated, widowed males	4.0	5.9	3.2	4.2	4.2	4.4	6.9	8.2
Never married males	7.6	3.3	11.9	7.4	2.6	3.1	2.4	1.9
Married females	35.1	32.1	36.8	45.1	38.2	35.7	22.8	22.8
Divorced, separated, widowed females	11.5	21.4	5.9	10.5	11.3	13.2	32.1	35.2
Never married females	6.3	3.3	9.0	6.0	2.8	3.1	3.8	2.3
Living arrangement								
Living with spouse	64.7	65.0	69.2	71.3	78.2	75.0	54.0	50.9
Living with other relatives	16.5	17.0	20.0	21.3	10.5	12.4	16.2	20.5
Living with nonrelatives	2.6	1.4	3.8	2.0	1.2	1.4	1.6	1.2
Living alone	11.2	16.7	7.0	5.5	10.1	11.1	28.2	27.4

APPENDIX H. (Continued)

Characteristic	Age (Years)							
	20+		20-44		45-64		65+	
	Nondiabetics	Diabetics	Nondiabetics	Diabetics	Nondiabetics	Diabetics	Nondiabetics	Diabetics
Usual activity								
Working	57.6	32.1	67.6	58.8	62.7	44.9	10.9	6.6
Keeping house (female)	28.1	40.1	22.5	31.1	27.7	35.6	48.9	8.9
Retired (age 45 years and over)	7.2	20.1	-	-	5.9	12.2	35.7	37.1
Retired, health (age 45 and over)	2.2	9.8	-	-	3.3	10.0	8.0	13.4
Other	7.0	7.7	9.7	10.1	3.4	7.3	4.3	7.3
Family income								
Under $3,000	6.3	10.6	4.8	4.9	4.8	7.9	14.6	16.0
$3,000-$4,999	8.1	15.4	5.7	9.4	6.0	11.7	20.9	22.0
$5,000-$6,999	8.8	13.3	7.6	11.1	7.4	11.6	15.6	16.2
$7,000-$9,999	11.5	11.5	11.8	11.9	10.5	11.1	12.6	11.8
$10,000-$14,999	20.7	15.6	24.0	23.4	19.7	18.5	10.7	9.1
$15,000-$24,999	23.3	14.9	27.3	26.1	24.2	18.4	7.4	6.4
$25,000 and over	12.5	7.0	12.3	5.9	16.8	9.2	4.8	5.0
Unknown	8.8	11.7	6.5	7.4	10.5	11.7	13.5	13.4
Region								
Northeast	23.5	23.9	22.5	18.1	25.4	24.5	23.3	25.4
North Central	26.6	25.8	26.6	26.1	26.3	25.6	27.3	25.9
South	31.7	35.1	31.7	38.7	31.2	35.4	32.4	33.3
West	18.2	15.3	19.2	17.4	17.1	14.5	17.0	15.4
Place of residence								
SMSA	68.9	66.0	70.2	66.7	69.3	68.5	63.7	62.9
Central city	29.8	32.8	29.6	32.9	29.1	32.9	31.9	32.6
Outside central city	39.1	33.2	40.5	33.8	40.2	35.6	31.8	30.2
Outside SMSA	31.1	34.0	29.8	33.2	30.7	31.5	36.3	37.1
Nonfarm	28.0	30.9	27.4	30.0	26.9	29.0	32.4	33.5
Farm	3.1	3.1	2.4	3.2	3.8	2.5	3.9	3.6

SOURCE: 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX I. *Ratio of urban to rural age-standardized rates of diabetes, United States, 1976*

Characteristic	Urban:Rural* Rate
Male	1.06
Female	0.88
White	0.91
Black	1.25
Total	0.95

*Urban: persons living in households within standard metropolitan statistical areas (SMSAs).
Rural: persons living outside of SMSAs.

SOURCE: 1976 Health Interview Survey, National Center for Health Statistics.

APPENDIX J. *Percent of employed persons, by occupational characteristics, United States, 1976 and 1977*

Characteristic	Age (Years)							
	20+		20-44		45-64		65+	
	Diabetics	All Persons	Diabetics	All Persons	Diabetics	All Persons	Diabetics	All Persons
Type of occupation								
Professional, technical, managerial, administrative	26.0	28.9	26.0	29.0	26.4	28.8	22.8	28.4
Sales	7.5	6.1	5.2	5.6	7.7	6.7	11.7	9.1
Clerical	14.3	17.1	16.6	18.3	13.4	15.6	13.5	9.6
Craftsmen	12.5	13.6	12.2	13.5	13.9	14.3	5.8	8.7
Operatives	17.1	15.2	18.7	15.9	17.8	14.7	9.3	7.5
Laborers, service workers	18.6	15.4	18.9	14.9	16.7	15.6	28.7	25.1
Farm-associated	3.5	2.8	1.2	2.1	3.8	3.4	8.7	11.1
Type of industry								
Construction	4.0	6.1	5.9	6.3	3.9	6.0	-	4.5
Manufacturing	23.9	24.2	26.2	24.1	25.5	25.1	11.1	8.7
Transportation, utilities	5.8	6.7	4.7	6.9	7.2	6.9	1.2	1.5
Wholesale, retail	20.2	18.0	20.1	18.3	18.7	17.1	28.7	20.4
Finance, insurance, real estate	4.6	5.7	4.7	5.2	4.7	5.4	4.1	8.1
Public administration	7.7	6.5	8.2	6.2	7.4	7.4	8.8	4.2
Services	27.7	27.9	26.9	28.0	26.8	26.5	34.5	39.1
Other	6.1	4.9	3.3	5.0	5.8	5.6	11.6	13.5
Source of wages								
Privately paid	68.6	72.4	74.9	75.1	67.4	68.6	60.2	59.0
Federal government	4.2	3.7	3.5	3.4	5.3	4.5	1.2	1.9
State government	3.6	4.2	4.4	4.4	3.9	4.1	-	1.4
Local government	10.5	9.2	10.1	9.3	10.7	9.3	10.5	6.7
Self-employed	11.6	8.9	5.4	6.3	11.6	11.8	26.9	29.7
Work experience								
None in past year	57.7	31.8	25.9	17.9	47.5	30.7	83.4	80.2
Any in past year	41.0	66.7	73.1	80.6	51.6	68.0	14.7	17.8
1-6 months	5.1	8.0	10.5	11.2	5.1	5.0	2.7	3.3
7-9 months	2.4	4.9	5.7	6.9	2.4	3.2	0.8	1.3
10-12 months	33.6	53.8	56.9	62.5	44.0	59.7	11.2	13.2
Year-round worker	31.2	50.5	51.4	57.8	41.7	57.5	10.4	12.4

SOURCE: 1976-77 National Health Interview Surveys, National Center for Health Statistics.

APPENDIX K. *Number and percent distribution by sex of diabetics and the general population age 20 years and older, United States, 1979-81*

Age (Years) and Race	General Population			Diabetics		
	Both Sexes (Thousands of Persons)	Percent Distribution		Both Sexes (Thousands of Persons)	Percent Distribution	
		Men	Women		Men	Women
All races						
All ages	148,995	47.1	52.9	5,337	43.3	56.7
20-24	20,141	48.4	51.6	76	37.7	62.3
25-29	18,625	48.7	51.3	124	43.7	56.3
30-34	17,068	48.7	51.3	168	39.4	60.6
35-39	13,747	47.8	52.2	200	37.0	63.0
40-44	11,661	48.7	51.3	241	44.6	55.4
45-49	11,007	48.5	51.5	403	48.8	51.3
50-54	11,566	48.1	51.9	563	46.2	53.8
55-59	11,227	47.2	52.8	719	46.9	53.1
60-64	9,925	46.8	53.2	725	48.5	51.5
65-69	8,689	44.0	56.0	730	44.3	55.7
70-74	6,561	42.7	57.3	608	42.4	57.6
75-79	4,503	38.6	61.4	492	35.9	64.1
80+	4,275	35.2	64.8	293	27.9	72.1
Whites						
All ages	131,086	47.4	52.6	4,429	44.4	55.6
20-34	48,116	49.2	50.8	307	38.9	61.1
35-49	31,838	48.8	51.2	655	45.6	54.4
50-64	29,326	47.6	52.4	1,628	48.8	51.2
65-79	17,866	42.4	57.6	1,580	42.9	57.1
80+	3,940	34.8	65.2	259	29.8	70.2
Blacks						
All ages	15,286	44.1	55.9	825	37.0	63.0
20-34	6,490	44.5	55.5	57	45.1	54.9
35-49	3,840	44.4	55.6	174	41.8	58.2
50-64	2,937	45.2	54.8	332	39.2	60.8
65-79	1,714	41.4	58.6	228	31.5	68.5
80+	304	38.5	61.5	34	13.4	86.6

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX L. *Number (thousands) of diagnosed diabetics, by duration of diabetes, United States, 1976*

Current Age	Number of Years With Diabetes			
	<5	5-9	10-19	20+
0-24	95	50	38	2
25-44	297	1,097	89	43
45-64	726	480	427	158
65+	568	419	376	257
Total	1,686	2,046	930	460
Percent of Total	34%	40%	18%	9%

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX M. *Percent of households with diabetic residents, United States, 1976*

	Number of Diabetics Per Household		
	0	1	2 or More
Family size			
1	98.2	1.9	0.0
2	93.0	6.8	0.3
3	94.5	5.2	0.3
4	95.6	4.2	0.2
5	95.5	4.3	0.2
6	94.5	5.1	0.4
7	94.4	5.3	0.2
8+	93.3	6.6	0.1
All	94.2	5.6	0.2
Age of head of household			
15-24 years	98.1	1.8	0.1
25-44 years	97.0	2.9	0.0
45-64 years	92.3	7.3	0.4
65+ years	89.0	10.4	0.6

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX N. *Percent of diabetics and nondiabetics who reported changing jobs or stopping work for a health reason, United States, 1976-80*

Diabetic Status and Effect on Job or Housework	Percent of Persons				
Age (Years):	20-74	20-44	45-54	55-64	65-74
Medical history of diabetes					
Changed to easier job, part-time work, reduced housework	12.5	18.0	11.5	13.7	8.6
Retired and/or stopped housework	8.6	2.7	7.7	11.5	10.1
Undiagnosed diabetics*					
Changed to easier job, part-time work, reduced housework	12.8	8.3	20.2	9.6	12.3
Retired and/or stopped housework	3.2	0.0	4.6	2.4	4.5
Impaired glucose tolerance*					
Changed to easier job, part-time work, reduced housework	8.7	4.1	1.6	23.8	5.5
Retired and/or stopped housework	5.1	0.0	7.6	4.1	8.7
Normal glucose tolerance*					
Changed to easier job, part-time work, reduced housework	8.7	8.4	8.8	10.8	6.2
Retired and/or stopped housework	1.5	0.2	2.3	3.3	5.5

*National Diabetes Data Group criteria and 75-gm 2-hour OGTT.

SOURCE: Harris, MI, National Diabetes Data Group, from the Second National Health and Nutrition Examination Survey (NHANES II), Medical History Question 75, "Have you ever changed your job or stopped working because of a health problem?"

CHAPTER VII. SOCIODEMOGRAPHIC CHARACTERISTICS OF ADULT DIABETICS

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SUMMARY

In 1981 there were about 5.6 million persons with known diabetes among United States civilians living in the community. All but 2 percent of these were 20 years of age or over. Adult diabetics are highly similar to the general adult population with respect to territorial distribution, veteran status (for men), marital status, and living arrangements, but they are quite different with respect to age structure, sex and race composition, educational attainment, labor force status, and annual family income distribution.

Adult diabetics as a group are much older than the general population of adults in the United States, and a smaller proportion of them are men. Although the vast majority are whites, there is a higher proportion of blacks and a lower proportion of whites than in the general population. About 6 percent of adult diabetics are of Hispanic origin, and about 15 percent are black.

The largest share of adult diabetics reside in the South; the smallest share, in the West. A majority reside in metropolitan areas, but diabetics are about equally divided among central city residents, metropolitan area residents outside the central city, and nonfarm residents outside metropolitan areas. Adult diabetics are less educated than the general population, at least as measured by the number of completed years of formal schooling. A majority are currently married, but diabetic men are much more likely to be married than diabetic women. A larger proportion of diabetic men and women are married than in the general population except in the age group 45-64 years. About 65 percent of diabetics live with a spouse, while living with relatives (16.6 percent) or living alone are about equally likely living arrangements (17.1 percent). Diabetics, particularly men under age 65 and women, are more likely than the general population to live in families with low annual incomes.

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Regardless of how participation in the work force is assessed, about one-third of adult diabetics are actively involved in the work force on a regular basis. However, such participation is substantially higher among younger diabetics and declines sharply with age. At all ages, men are much more likely than women to be in the work force, a situation seen in the nondiabetic population also. The occupational and industrial profile of currently employed diabetics is quite similar to that of the general employed population. About half of employed diabetics are in white-collar jobs; about three in ten, in blue-collar jobs; about one in five, in service jobs. Three major industrial settings—service industries, manufacturing, and wholesale/retail industries—account for three-fourths of the employed diabetic population. About three out of four employed diabetics are in privately paid jobs, although a substantial minority work for government at the Federal, State, or local level.

INTRODUCTION

Demographic factors play a major role in descriptive epidemiological analyses of diabetes (West 1978). A major objective of such studies is to describe the relative frequency of diabetes among various sociodemographic groups of the population. In the United States, for example, diabetes is proportionately more common among older people, women, blacks, the less educated, and persons in families with low annual incomes (Drury et al. 1981). These variations in the prevalence of diabetes have an important impact on the sociodemography of the diabetic population, and such information has important implications for programming health education and other health care services for persons with diabetes, and for planning epidemiological analyses of specific issues involving comparisons of diabetics and nondiabetics.

SOURCES OF DATA

The data for this chapter come primarily from the National Health Interview Survey (NHIS) of the National Center for Health Statistics (NCHS). The NHIS is a continuous household interview survey of the health of the civilian, noninstitutional population in the 50 United States. It is based on a large, scientifically selected sample; details of the procedures used in the NHIS to identify persons with selected chronic conditions, including known diabetes, have been published (NCHS 1975) and technical information on the NHIS for the 1979-81 time period is available (Jack and Ries 1981, Jack 1981, Bloom 1982). Since its inception in 1957 (Bollo 1960), the NHIS has collected information on the prevalence of known diabetes and on the sociodemographic and health characteristics of persons with known diabetes (NCHS 1967, McDonald 1968, Fuchsberg 1968, Holland 1968, Stulb 1968). The major data sources in this chapter are the 1979, 1980, and 1981 NHIS surveys, although medical history data from NHIS conducted during other years are used to supplement the description of the sociodemography of the diabetic population.

During the 1979-81 NHIS, questions about diabetes were asked in approximately 39,615 households. Based on responses to these questions, 2,641 persons were identified as known diabetics; of these, 2,595 were adults ages 20 years or older. About 70 percent of these adult diabetics responded to the NHIS interview for themselves, and the majority of proxy responses were by spouses. Because the NHIS collects information only about the civilian, noninstitutionalized population, persons in the military or living in institutions are not included. However, data on diabetes among nursing home residents from the 1977 National Nursing Home Survey indicate that, while about 14 percent of nursing home residents have diabetes (Hing 1981), diabetics in these facilities represent only about 1 percent of all diabetics in the United States. Diabetes among the military population is insignificant. Persons less than 20 years old are also not included in these analyses, because the demography of children and youths with diagnosed diabetes ascertained through household interviews presents special problems of analysis and interpretation (Drury et al. 1979).

The NHIS data are in some ways less than ideal for carrying out demographic analyses of the diabetic population. For example, no clinical confirmation of a diagnosis of diabetes is possible in a medical history interview, nor is it possible to ascertain undiagnosed diabetes. Also, reports on diabetes are limited to known diabetics in the household which a person (sometimes a proxy) is willing to report. A record-check study conducted in 1962 showed that only about 1 percent of persons reported having diabetes when they actually did not have diabetes on their medical record, and that about 15 percent failed to tell the interviewer that they had diabetes when it was on their medical record (Madow 1973). Virtually everyone identified in household interviews as being diabetic had been informed of the condition by a physician. There is some evidence (from studies of registries and small community-based studies that have included a reevaluation of the basis of the diagnosis) that a certain amount of patient misunderstanding of what the physician said, as well as physician misdiagnosis or overdiagnosis, is present in household reports of diabetes. However, data from the 1976-80 National Health and Nutrition Examination Survey (NHANES) and the 1976 NHIS bear on the validity of a previous diagnosis of diabetes in respondents. Among the 756 NHANES II subjects who reported a medical history of physician-diagnosed diabetes, 26 percent were currently taking insulin and 35 percent were currently taking oral antidiabetic medication. An additional 14 percent had been given a written diet for control of their diabetes and were following their diets. Thus, 25 percent of persons were not on any of these three therapies at the time of the survey; however, virtually all of these had a history of use of insulin, oral antidiabetic agents, or diet (Harris 1984). Similar results on past and current use of diabetes therapies were reported by the 2,442 NHIS respondents who indicated that they were diabetic from among the 113,000 persons who participated in NHIS in 1976. Consequently, it is likely that those who report a physician's diagnosis of diabetes do indeed have diabetes.

Although it is widely recognized that the term "diabetes mellitus" refers to a heterogeneous group of disorders that share glucose intolerance in common, it is not possible to tabulate NHIS diabetes data to identify different types of diabetics. The proportion of diabetics who may be the insulin-dependent type, based on 1976 NHIS information about age at diagnosis (less than 20 years), history of insulin use (equal to the duration of diabetes), and weight relative to height (less than 20 percent above ideal body weight), appears to be only about 5 to 10 percent of all known diabetics; about half of these are currently age 20 years and over (Harris 1982). Given that the NHIS sample of diabetics is mainly composed of noninsulin-dependent diabetics, one should be cautious in generalizing the descriptions in this chapter to insulin-dependent diabetics.

DEMOGRAPHIC COMPOSITION OF THE DIABETIC POPULATION

In 1981 there were about 5.6 million persons with known diabetes in the United States civilian population living outside of institutions; about 98.4 percent of them (5.5 million persons) were 20 years of age and over. This proportion was virtually constant throughout the decade of the 1970s. Virtually all (99.7 percent) of these diabetics reported that they had seen a physician at some time in their lives for their diabetes, and about four out of five (82.5 percent) had seen a physician for their diabetes one or more times in the past 12 months. The age composition of this adult diabetic population contrasts sharply with that of the general population of adults, as do the sex and racial/ethnic composition.

Age Composition

Perhaps the most striking feature of the demographic structure of the diabetic population is its age composition (Table 1, Figure 1). The vast majority of diabetics are not only adults, but older adults. During 1979-81, for example, of 5.3 million adult diabetics, 40 percent were 65 years or older; 53 percent, 60 years or older; and about 85 percent, 45 years or older. The older age of diabetics contrasts sharply with the age composition of the general adult population in the United States. While the median age of adult diabetics was about 61 years during 1979-81, the median age of all persons 20 years of age and over was only about 42 years (Appendix A). This relative difference in the median ages of diabetics and the general population occurred among all race-sex groups.

Sex Composition

The majority of adults ages 20 years and over in the United States are women (52.9 percent), although the percent is higher among diabetics (56.7 percent) (Figure 1). The difference in the sex composition of diabetics versus the general population primarily reflects the higher percentages of diabetic women in the youngest and oldest age categories (Appendix B). In 1979-81, there were only about 77 men with diabetes for every 100 diabetic women, while in the general population this ratio was 89 to 100. Among blacks, the ratios were about 59 per 100 for diabetics and 79 per 100 for the general population (Appendix C). Sex ratio differences between diabetics and the general population varied by race. For example, among blacks at age 50 and older, there were far fewer diabetic men per 100 women than in the general population of blacks; for whites this discrepancy occurred at age 80 years and over, although both races had low ratios in the youngest age groups (Appendix C).

TABLE 1. *Number and percent distribution of diabetics and the general population age 20 years and older, by age, sex, and race, United States, 1979-81*

Age and Race	General Population			Diabetics		
	Both Sexes	Men	Women	Both Sexes	Men	Women
All races						
Number (thousands):	148,995	70,108	78,886	5,337	2,314	3,023
			Percent Distribution			
Age (years)						
20-24	13.5	13.9	13.2	1.4	1.2	1.6
25-29	12.5	12.9	12.1	2.4	2.4	2.3
30-34	11.5	11.8	11.1	3.3	3.0	3.5
35-39	9.2	9.4	9.1	3.7	3.2	4.1
40-44	7.8	8.1	7.6	4.5	4.6	4.4
45-49	7.4	7.6	7.2	7.6	8.5	6.8
50-54	7.8	7.9	7.6	10.5	11.2	10.0
55-59	7.5	7.6	7.5	13.4	14.5	12.6
60-64	6.7	6.6	6.7	13.5	15.1	12.3
65-69	5.8	5.5	6.2	13.6	13.9	13.4
70-74	4.4	4.0	4.8	11.4	11.1	11.5
75-79	3.0	2.5	3.5	9.2	7.6	10.4
80+	2.9	2.1	3.5	5.5	3.5	7.0
Whites						
Number (thousands)	131,086	62,123	68,963	4,429	1,968	2,461
			Percent Distribution			
Age (years)						
20-34	36.7	38.1	35.4	7.1	6.2	7.8
35-49	24.3	25.0	23.6	14.7	15.1	14.4
50-64	22.4	22.5	22.3	36.7	40.3	33.8
65-79	13.6	12.2	14.9	35.6	34.4	36.5
80+	3.0	2.2	3.7	5.9	3.9	7.4
Blacks						
Number (thousands)	15,286	6,747	8,538	825	305	520
			Percent Distribution			
Age (years)						
20-34	42.5	42.8	42.2	6.9	8.4	6.0
35-49	25.1	25.3	25.0	21.1	23.9	19.5
50-64	19.2	19.7	18.9	40.3	42.7	38.9
65-79	11.2	10.5	11.8	27.7	23.6	30.1
80+	2.0	1.7	2.2	4.1	1.5	5.6

SOURCE: National Center for Health Statistics. Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

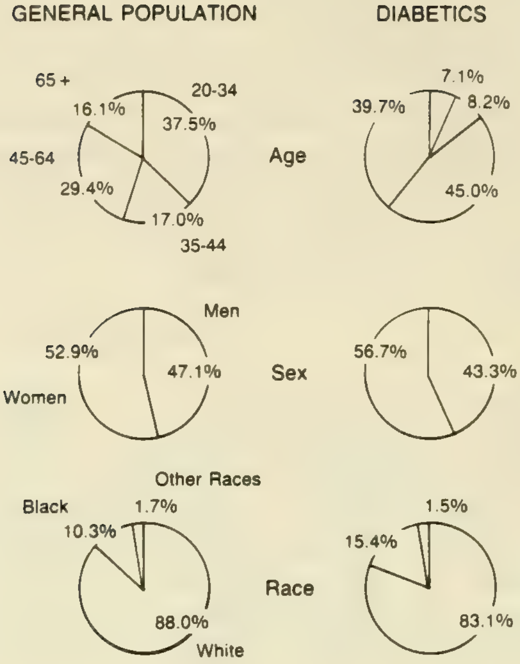

FIGURE 1. *Age, sex, and race composition of diabetics and the general population 20 years of age and older, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Race Composition

About four out of five adult diabetics (83.1 percent) are whites; about one out of seven (15.4 percent) are blacks, and the remaining 1.5 percent are persons of other racial backgrounds (Figure 1). While the majority of diabetics are whites, the diabetic population has a higher proportion of blacks and a lower proportion of whites than does the general population (Table 2, Appendix D). For every 100 white diabetics there are about 18.6 black diabetics, while in the general population the ratio is 100 to 11.7. Among men, this black/white ratio is somewhat lower (15.5); among women, somewhat higher (21.1). Among diabetics 35 to 49 years of age there are as many as 27 blacks for every 100 whites; among diabetics 80 years and over, as few as 13 blacks for every 100 whites. Among men and women 35 years and over, the black/white ratios decrease with age; among the diabetic population the decline does not begin until age 50 years, reflecting the older age of diabetics. In all but one instance (men 80 years and over), the black/white ratio is higher among diabetics than it is among the general population. This is particularly true for age categories between 35 and 64.

TABLE 2. *Number of blacks per 100 whites for diabetics and the general population age 20 years and older, by age and sex, United States, 1979-81*

	Both Sexes		Men		Women	
Age (Years)	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
20+	11.7	18.6	10.9	15.5	12.4	21.1
20-34	13.5	18.4	12.2	21.8	14.7	16.3
35-49	12.1	26.6	11.0	24.3	13.1	28.5
50-64	10.0	20.4	9.5	16.4	10.5	24.3
65-79	9.6	14.4	9.4	10.6	9.8	17.3
80+	7.7	13.1	8.5	5.8	7.3	16.2

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Age-Sex-Race Composition

The population pyramids shown in Figure 2 describe the distribution of the adult diabetic population by age, sex, and race. Comparison of the two pyramids in the top panel of Figure 2 reveals how different the age composition of the diabetic population is from the general population. The longer bars for diabetics at the top of the pyramid reflect the much higher proportion of diabetics in older age categories. The lack of symmetry in the pyramid for diabetics under age 40 and above age 79 reflects the fact that there are more women than men in these age categories. The approximate symmetry in this pyramid between ages 40 to 79 indicates that at these ages diabetics are more evenly distributed between the sexes. Comparison of the pyramids for diabetics in the bottom and middle panels of Figure 2 shows how different the age-sex composition of black diabetics is from that of white diabetics. The bottom panel highlights how much older and predominantly female is the composition of the black diabetic group compared to the general population of blacks 20 years of age and over.

The pyramids in Figure 3 contrast the distribution of the diabetic population and the general population by age, sex, and racial background. Despite the lower relative prevalence of diagnosed diabetes among whites, the vast majority of each age-sex group of diabetics are whites because of the greater number of whites in the population. The demographic impact of the greater rate of diabetes among blacks is shown by blacks between ages 50 and 79, representing a larger share of each age-sex group of diabetics than they do of each comparable age-sex category of the general population.

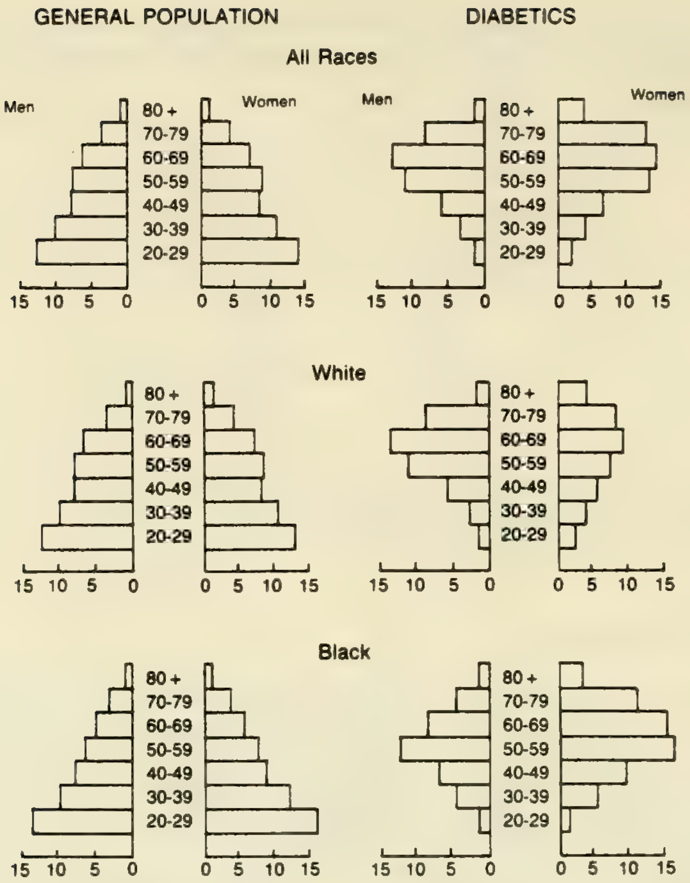

FIGURE 2. *Age-sex composition of diabetics and the general population 20 years of age and over by race, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Racial/Ethnic Origins

Approximately 15 percent of adult diabetics are black (Figure 1). Detailed information on the ethnic origins of known diabetics based on national probability samples is limited by small sample sizes, conceptual confusion in classification, and inaccuracies in reporting race and ethnicity (Drury et al. 1980). Despite these caveats, data from two surveys provide information on the ethnic origins of known diabetics. Data from the 1971-1974 National Health and Nutrition Examination Survey indicate that about half (55.6 percent) of known diabetics 20-74 years of age have Western European origins, primarily German, English, and Irish (Table 3). An additional 5 percent trace their ethnic origins to the Eastern European countries of Poland (2.6 percent) and Russia (2.4 percent). These percentages for diabetics are similar to those for the general population 20 to 74 years of age (Table 3). About 6 percent of adult diabetics have Hispanic origins, which is similar to the general population (Table 4). Among diabetics in their middle years, however, as many as 8.2 percent have Hispanic origins, whereas

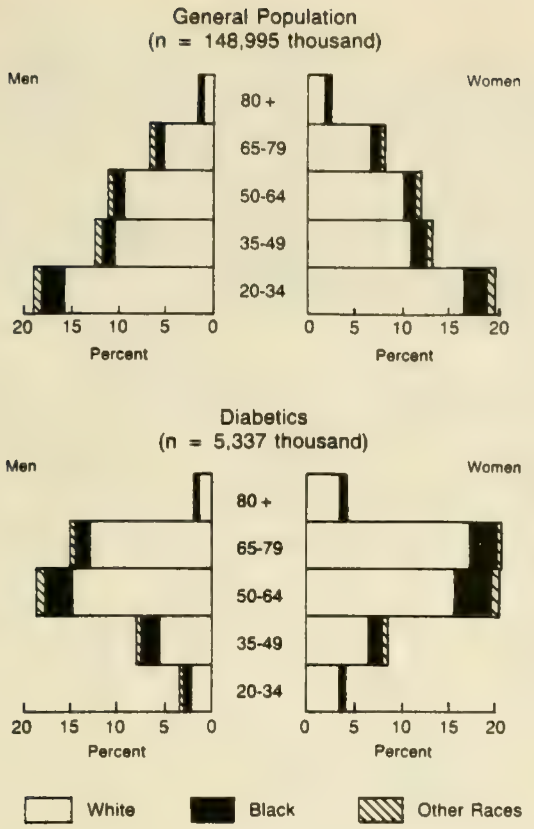

FIGURE 3. *Age-sex-race composition of diabetics and the general population 20 years of age and over, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

TABLE 3. *Percent of diabetics and the general population age 20-74 years with European ethnic origins, United States, 1971-74*

Ethnic Origin	General Population	Diabetics
Western European	57.8	55.6
Germany	18.8	14.1
England	15.5	15.5
Ireland	14.3	15.3
France	5.1	7.1
Italy	4.1	3.6
Eastern European	5.1	5.0
Poland	3.6	2.6
Russia	1.5	2.4

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1971-74 National Health and Nutrition Examination Survey data provided by the Division of Health Examination Statistics, National Center for Health Statistics.

only about 5 percent of the general population in this age range is Hispanic. This higher percentage of Hispanics among middle-aged diabetics primarily reflects the higher proportion of Hispanics among diabetic women in their middle years (Table 4).

TABLE 4. *Numbers of persons (thousands) and percent with Hispanic origin among diabetics and the general population ages 20 years and older, United States, 1979-81*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Total number of persons*	148,262	5,317	80,810	804	43,529	2,400	23,924	2,112
Number of Hispanic origin	9,044	321	6,061	60	2,176	197	766	64
Percent of Hispanic origin	6.1	6.0	7.5	7.4	5.0	8.2	3.2	3.0
Men								
Total number of men*	69,756	2,306	39,180	326	20,746	1,145	9,830	836
Number of Hispanic origin	4,255	124	2,899	27	1,037	77	315	20
Percent of Hispanic origin	6.1	5.4	7.4	8.3	5.0	6.7	3.2	2.4
Women								
Total number of women*	78,506	3,011	41,630	479	22,782	1,256	14,094	1,276
Number of Hispanic origin	4,710	197	3,122	33	1,139	120	437	44
Percent of Hispanic origin	6.0	6.5	7.5	6.9	5.0	9.6	3.1	3.4

*Excludes persons with unknown origin.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

TERRITORIAL DISTRIBUTION

Region

Adult diabetics are quite similar to the general population with respect to their regional distribution. The largest share (36.2 percent) of the adult diabetic population resides in the South (Table 5). The next largest shares reside in the North Central (26.1 percent) and Northeast (22.4 percent) regions. The West, with 15.2 percent, has the smallest population of adult diabetics. These proportions are similar to the distribution of the general United States population.

TABLE 5. *Geographic location of diabetics and the general population age 20 years and older, United States, 1979-81**

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Number (thousands)	148,995	5,337	81,243	809	43,725	2,406	24,027	2,123
	Percent Distribution							
Region								
Northeast	22.5	22.4	21.5	20.9	23.7	22.3	23.9	23.2
North Central	26.3	26.1	26.6	28.1	26.0	26.0	25.7	25.4
South	32.4	36.2	32.2	33.2	32.3	37.8	33.0	35.6
West	18.8	15.2	19.6	17.7	18.0	13.8	17.4	15.8
Location of residence								
Within SMSA	68.8	66.3	70.1	68.2	68.8	69.0	64.2	62.6
Central city	28.3	31.1	28.3	31.2	27.4	32.7	29.7	29.1
Outside central city	40.5	35.3	41.8	37.0	41.4	36.2	34.6	33.5
Outside SMSA	31.2	33.7	29.9	31.8	31.2	31.0	35.8	37.4
Nonfarm	28.6	31.1	27.8	30.9	27.8	28.6	32.5	34.1
Farm	2.7	2.5	2.1	1.0	3.4	2.4	3.3	3.3
Size of place**								
Within SMSA								
Less than 250,000 pop.	8.5	8.6	8.9	10.2	8.3	8.0	7.6	8.5
250,000 to 499,999 pop.	9.5	10.1	10.0	10.5	9.0	10.3	9.0	9.6
500,000 to 999,999 pop.	10.8	10.2	10.9	9.3	11.0	11.0	9.6	9.7
1 million to 2,999,000 pop.	21.7	20.8	22.5	23.4	21.4	21.7	19.7	18.7
3 million or more	18.8	18.5	18.8	20.3	19.3	17.9	18.1	18.4
Outside SMSA								
Rural area	18.7	19.0	17.4	15.6	19.5	19.2	21.1	20.3
Urban area	12.0	12.9	11.4	10.7	11.6	11.9	14.8	14.9

*Percent distribution for men and women is shown in Appendix F.

**Data on size of place are for 1973.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1973 and 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Location of Residence

Two thirds (66.3 percent) of adult diabetics are metropolitan area residents (Table 5). This majority is about evenly split between residents in the central city (31.1 percent) and in places outside the central city (35.3 percent). The remaining third living outside metropolitan areas reside primarily in nonfarm areas (31.1 percent), with only about 2.5 percent living on farms; this does not necessarily mean, of course, that they are farmers. About four-fifths of diabetics in the Northeast and West reside in metropolitan areas; in the South, about 54 percent; and in the North Central region, about two-thirds, which is similar to the national average for diabetics. The region-location of residence distributions of diabetics basically follow general population patterns (Appendix E). Estimates of the distribution of diabetics among Standard Metropolitan Statistical Areas (SMSAs) by region are shown in Table 6.

TABLE 6. *Percent of diabetics and the general population age 20 years and older residing in certain large SMSAs, United States, 1973*

Region and City	General Population	Diabetics
Northeast		
New York	32.8	31.6
Philadelphia	9.3	10.8
Boston	5.3	4.6
Pittsburgh	4.6	4.7
Buffalo	2.7	3.9
All other	45.3	44.4
North Central		
Chicago	13.3	11.5
Detroit	7.5	9.0
St. Louis	4.0	2.7
Cleveland	4.0	4.3
Minneapolis-St. Paul	3.2	2.5
Milwaukee	2.7	2.1
Kansas City	2.3	1.8
Indianapolis	2.0	1.6
Cincinnati	2.0	1.6
All other	59.0	62.9
South		
District of Columbia	4.7	4.3
Baltimore	3.5	4.0
Houston	3.3	3.2
Dallas	2.7	2.3
Atlanta	2.5	1.4
Miami	2.2	1.6
Tampa	1.7	2.3
New Orleans	1.6	1.9
All other	77.8	79.0
West		
Los Angeles/Long Beach	20.2	21.9
San Francisco/Oakland	9.1	6.9
Anaheim/Santa Ana/Garden Grove	4.7	3.4
Seattle/Everett	4.3	5.1
Denver	3.9	2.9
San Diego	3.7	5.2
San Jose	3.2	2.7
San Bernardino/Riverside/Ontario	3.1	5.2
Portland	3.0	4.1
All other	44.8	42.6

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1973 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

If one examines these data to estimate the proportion of the audience for diabetes educational campaigns that might be reached by focusing on selected large SMSAs, it becomes clear that there are large differences among the regions not only in the proportion of diabetics that might be reached by targeting large SMSAs, but also in the number of large SMSAs that would have to be targeted to reach the same proportion of diabetics. In the Northeast and West regions, educational campaigns focused on large SMSAs could potentially reach about half the adult diabetics. In the North Central and South regions, however, only about a third (34 percent) and a fifth (21 percent) of diabetics would be potentially reachable. Moreover, while about the same proportion of diabetics might be reached by focusing on large SMSAs in the Northeast and the West, only five large SMSAs would have to be targeted to reach this same proportion in the Northeast, contrasted with nine large SMSAs in the West.

Size of Place

The vast majority of adult diabetics reside in metropolitan areas, but diabetics are highly similar to the general population with respect to the size of place distribution of their residences. This similarity occurred throughout the 1970s. Since population shifts after 1970 may confound the absolute meaning of the 1970 size of place classifications of the NHIS sample points, the data for the most recent time interval (1979-81) are not shown. In 1973, about 18.5 percent of adult diabetics lived in localities with a population size of three million or more, and 20.8 percent lived in places with one to three million inhabitants (Table 5). About 10.2 percent lived in places with 500,000 to a million persons and 10.1 percent in places with 250,000 to a half million persons. About 8.5 percent lived in SMSAs with fewer than 250,000 inhabitants. Of the remaining 32 percent of adult diabetics living in areas outside of SMSAs, 19 percent were located primarily in rural areas (Table 5). Estimates by sex are shown in Appendix F.

SOCIAL COMPOSITION

Educational Attainment

Adult diabetics have less formal education than the general population of persons age 20 years and over. One indicator of this is the percent with fewer than 12 completed years of formal schooling. In 1979-81, 54.0 percent of adult diabetics had fewer than 12 years of schooling, while only 29.4 percent of adults in the general population had less than a high school education (Table 7, Figure 4). The percent of persons with fewer than 12 years of education increased with age among both diabetics and the general population. About 5.1 percent of persons with less than a high school education have diabetes, but only about 2.6 percent of persons with at least some college have diabetes (Drury et al. 1979). Since diabetics as a group are so much older, one might suppose that diabetics have less formal schooling simply because they are older. But as the data in Table 7 show, the lower educational attainment of diabetics is only partly a result of their older age structure. In addition, although only 3.3 percent of all adults in 1979-81 reported that their usual activity was attending school, this was the primary activity of only 0.4 percent of adult diabetics (see Table 10).

TABLE 7. *Years of school completed by diabetics and the general population age 20 years and older, United States, 1979-81**

Years of School	Age (Years)							
	20 and over		20-44		45-64		65 and over	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Number (thousands)	146,712	5,258	80,404	798	42,942	2,380	23,366	2,079
				Percent Distribution				
8 or less	15.3	35.9	5.8	12.8	18.7	30.5	41.9	51.1
9 to 11	14.0	18.1	12.2	16.5	16.4	19.5	16.1	17.1
12	37.8	28.2	41.3	37.6	38.6	34.1	24.3	17.9
13 to 15	16.8	9.0	21.5	17.2	12.4	7.6	8.8	7.5
16 or more	16.0	8.7	19.2	15.9	13.9	8.3	9.0	6.4
Men								
Number (thousands)	68,975	2,280	38,942	326	20,421	1,127	9,613	828
				Percent Distribution				
8 or less	15.7	31.1	6.2	13.0	20.2	24.9	44.6	46.8
9 to 11	13.3	16.3	11.7	14.5	15.5	16.7	15.1	16.5
12	34.3	29.1	38.0	34.9	33.4	36.8	21.4	16.2
13 to 15	17.3	9.9	22.1	16.2	12.6	8.8	8.0	8.8
16 or more	19.4	13.6	22.0	21.3	18.3	12.7	10.9	11.9
Women								
Number (thousands)	77,736	2,978	44,462	473	22,521	1,253	13,754	1,252
				Percent Distribution				
8 or less	15.0	39.6	5.5	12.6	17.3	35.5	40.0	54.0
9 to 11	14.7	19.5	12.6	18.0	17.2	22.0	16.7	17.5
12	40.8	27.6	44.4	39.5	43.3	31.6	26.3	19.1
13 to 15	16.4	8.3	20.9	17.9	12.3	6.4	9.3	6.6
16 or more	13.1	5.0	16.6	12.1	9.9	4.5	7.7	2.8

*Excludes persons with unknown years of school completed.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

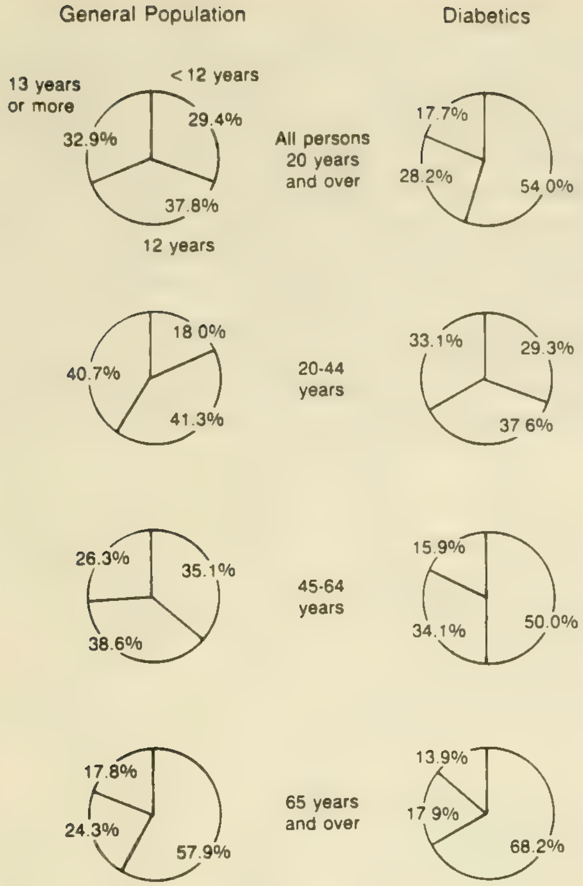

FIGURE 4. *Individual educational attainment of diabetics and the general population 20 years of age and over, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Marital Status

About two out of three adult diabetics (65.6 percent) are married, but this percentage varies importantly with age and sex (Figure 5, Table 8). While about 7 of 10 diabetics age 20 to 64 years are currently married, substantially fewer (56.3 percent) diabetics age 65 years and over are married. While about one of seven young adult diabetics are formerly married (primarily divorced and separated), as many as two of five elderly diabetics are formerly married (primarily widows and widowers). "Never marrieds" compose only about 6 percent of all diabetics, but represent 15 percent of diabetics age 20 to 44 years. There are significant differences between men and women diabetics with respect to marital status. Overall, about four of five (80.5 percent) diabetic men are currently married, while only about half (54.2 percent) of diabetic women are currently married. This disparity occurs among all age groups, but it is more pronounced with increasing age. While the percent of diabetic men who are married tends to remain constant with age, the percent of diabetic women who are currently married decreases with age, from 69.3 percent for young women to 40.2 percent among elderly women. About one of seven diabetic men is formerly married. There is little age variation in this proportion among diabetic men, although there are differences in the types of formerly married status in younger and older age categories of diabetic men. The majority of formerly married men age 20-44 years were divorced, while the majority of formerly married men age 65 years and over were widowed. Among diabetic women, two of five are formerly married, and the proportion in this category increases with age. Among elderly diabetic women, 56 percent are formerly married, and virtually all women in this marital status category are widows. The composition of formerly married diabetic women at each age follows the same pattern as has been observed for men. By and large, patterns in the proportions of formerly married diabetic men and women are quite similar to those in the general population.

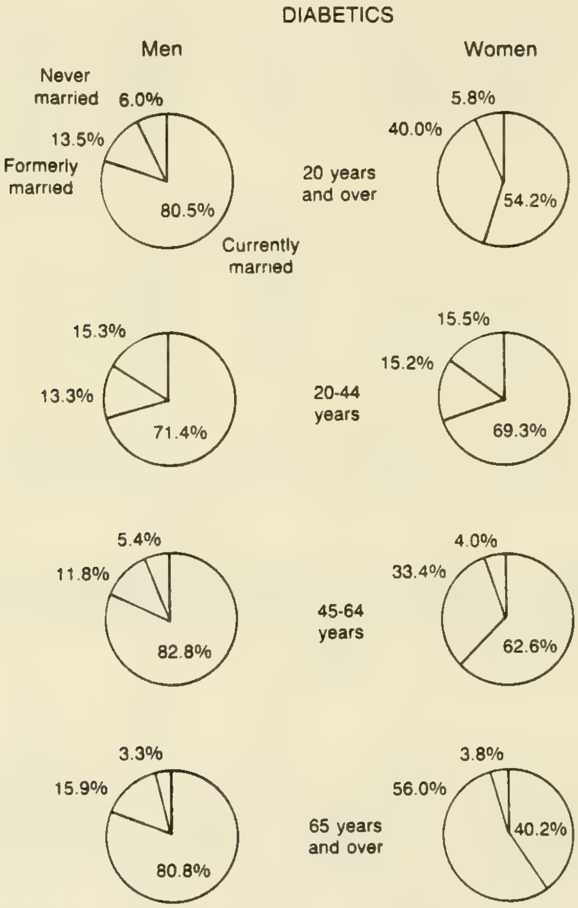

FIGURE 5. *Marital status of diabetics 20 years of age and over by age and sex, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

TABLE 8. *Marital status of diabetics and the general population age 20 years and older, United States, 1979-81**

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
Marital Status	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Number (thousands)	148,995	5,337	81,243	809	43,725	2,406	24,027	2,123
			Percent Distribution					
Married	68.2	65.6	66.4	70.1	78.9	72.2	54.8	56.3
Formerly married	16.7	28.5	10.1	14.5	16.3	23.1	39.6	40.1
Widowed	8.1	20.8	0.6	1.3	7.4	12.7	35.0	37.4
Divorced	6.1	5.2	6.7	9.8	6.6	6.5	3.3	1.9
Separated	2.4	2.6	2.9	3.4	2.3	3.9	1.2	0.8
Never married	15.1	5.9	23.5	15.4	4.8	4.7	5.6	3.6
Men								
Number (thousands)	70,108	2,314	39,386	328	20,847	1,146	9,874	840
			Percent Distribution					
Married	72.8	80.5	65.3	71.4	85.0	82.8	77.2	80.8
Formerly married	9.6	13.5	7.3	13.3	9.9	11.8	18.0	15.9
Widowed	2.8	6.9	0.2	1.4	2.8	4.6	13.7	12.4
Divorced	4.9	4.7	5.2	9.5	5.3	4.7	2.9	2.6
Separated	1.9	1.9	2.0	2.5	1.9	2.5	1.3	0.9
Never married	17.6	6.0	27.4	15.3	5.1	5.4	4.8	3.3
Women								
Number (thousands)	78,886	3,023	41,856	481	22,878	1,259	14,153	1,283
			Percent Distribution					
Married	64.1	54.2	67.4	69.3	73.3	62.6	39.1	40.2
Formerly married	23.0	40.0	12.7	15.2	22.2	33.3	54.7	56.0
Widowed	12.8	31.4	0.9	1.3	11.7	20.0	49.9	53.8
Divorced	7.2	5.6	8.1	10.0	7.8	8.1	3.6	1.4
Separated	3.0	3.1	3.7	4.0	2.7	5.2	1.2	0.7
Never married	13.0	5.8	19.9	15.5	4.5	4.0	6.2	3.8

*Excludes persons whose marital status was unknown.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Living Arrangements

Patterns of living arrangements among diabetics closely follow those in the general population. Living arrangements in the United States are largely a concomitant of an individual's marital status. The majority (64.7 percent) of adult diabetics and of the general population (67.4 percent) are married and living with their spouses (Table 9, Figure 6). As noted above, however, there are age and sex differences among diabetics in the relative likelihood of being currently married, and these differences are reflected in the percentages estimated to be living with spouses among the various age categories of diabetic men and women. Among diabetics who are not currently married, living with relatives (16.6 percent) and living alone (17.1 percent) are about equally likely living arrangements. Living with nonrelatives (1.7 percent) is, by contrast, quite a rare type of living arrangement for an adult diabetic. These proportions are also seen in the general United States population. This does not mean that there are no age differences in these latter types of living arrangements for diabetic men and women. Young diabetic men, for example, are about twice as likely as older diabetic men to be living with relatives. More notable, however, is the increase in each age category of diabetic women of the percent living alone, ranging from 4.6 percent among the youngest group to 35.5 percent among elderly diabetic women.

TABLE 9. *Living arrangements of diabetics and the general population age 20 years and older, United States, 1979-81*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
Living Arrangement	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Number (thousands)	148,995	5,337	81,243	809	43,725	2,406	24,027	2,123
			Percent Distribution					
With spouse	67.4	64.7	65.6	69.2	78.2	71.4	54.0	55.5
With relatives	17.1	16.6	21.4	22.0	10.2	14.2	15.0	17.2
With nonrelatives	3.0	1.7	4.5	3.1	1.1	1.2	1.4	1.6
Alone	12.5	17.1	8.5	5.7	10.5	13.2	29.7	25.8
Men								
Number (thousands)	70,108	2,314	39,386	328	20,847	1,146	9,874	840
			Percent Distribution					
With spouse	72.1	79.6	64.6	71.4	84.3	81.5	76.2	80.2
With relatives	14.0	8.5	19.8	16.0	6.2	6.4	7.6	8.4
With nonrelatives	3.5	1.6	5.3	5.2	1.1	1.3	1.1	0.5
Alone	10.4	10.4	10.4	7.4	8.3	10.8	15.1	11.0
Women								
Number (thousands)	78,886	3,023	41,856	481	22,878	1,259	14,153	1,283
			Percent Distribution					
With spouse	63.3	53.4	66.6	67.6	72.6	62.2	38.5	39.3
With relatives	19.8	22.8	23.0	26.1	13.9	21.3	20.1	22.9
With nonrelatives	2.5	1.7	3.7	1.7	1.1	1.2	1.6	2.3
Alone	14.4	22.2	6.8	4.6	12.5	15.3	39.9	35.5

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

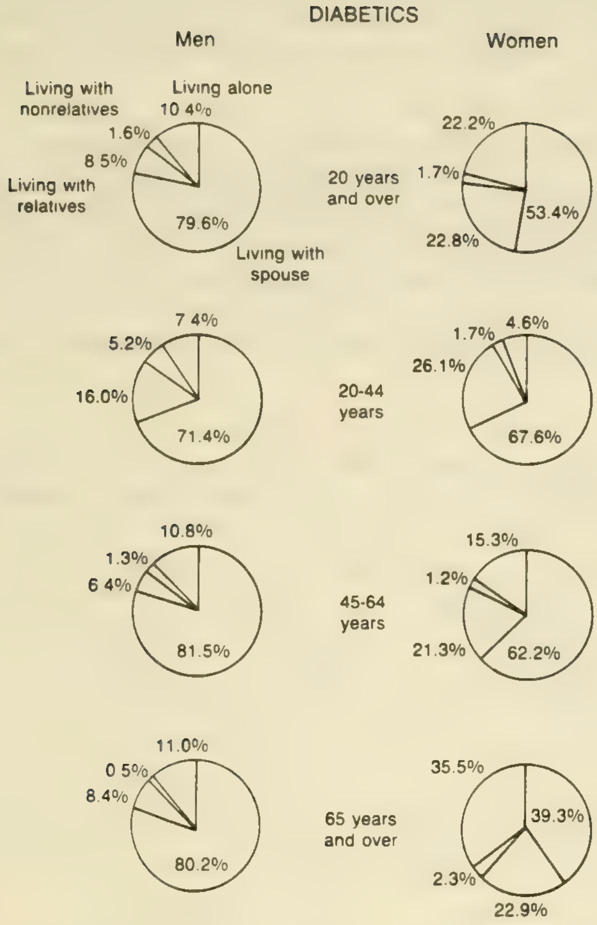

FIGURE 6. *Living arrangements of diabetics 20 years of age and over by age and sex, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

EMPLOYMENT CHARACTERISTICS

Participation in the world of work and employment characteristics are two areas of the sociodemographic profile of the adult diabetic subpopulation that are central to an understanding of the impact of diabetes on a person's life.

Participation in the Work Force

Compared to the general population, diabetic men and women are less likely to be working (Table 10) or in the labor force (Table 11). However, there are limitations in using the unemployment rate as a measure of joblessness because persons who may have stopped looking for a job when times were bad (the so-called "discouraged workers") are not reflected in the unemployment rates because they are not considered to be part of the labor force (Johnson 1983). Despite the lower participation of diabetics in the work force compared to that of the general population, the vast majority (94.9 percent) of diabetics who were in the work force in 1979-81 actually had a job or business in which they were employed. Their employment status was virtually identical to that of nondiabetics.

In each age group, a lower proportion of diabetics reported that working was their usual activity during the previous year (Table 10). Of diabetic men age 45 years or over, 44 percent were retired, half for health reasons. In the general population of the same age, only 15 percent were retired, and only one-third of these were retired for health reasons. Although a much smaller proportion of women than men in the United States are retired, the same disproportionate total retirement rates and retirement for health reasons occurred among diabetic women compared to the general adult female population.

TABLE 10. *Usual activity during the previous year of diabetics and the general population, age 20 years and older, United States, 1979-81**

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
Usual Activity	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Men								
Number (thousands)	70,002	2,314	39,328	328	20,812	1,146	9,862	840
			Percent Distribution					
Working	76.1	47.9	88.0	79.8	81.1	64.6	17.7	12.5
Retired	15.2	44.2	-	-	13.9	27.9	78.9	84.1
Retired for health	5.0	21.0	-	-	8.2	20.8	17.9	29.7
Other	8.7	7.9	12.0	20.2	5.0	7.5	3.4	3.4
Going to school	3.7	0.4	6.4	2.4	0.2	0.2	0.2	-
Women								
Number (thousands)	78,757	3,019	41,793	481	22,836	1,258	14,128	1,281
			Percent Distribution					
Working	45.8	20.8	58.1	42.3	47.0	28.6	7.5	5.0
Keeping house	47.5	68.8	35.3	54.8	49.8	63.2	79.8	79.5
Retired	1.8	3.8	-	-	1.5	2.7	7.5	6.2
Retired for health	0.6	2.2	-	-	0.7	1.9	1.9	3.4
Other	5.0	6.7	6.6	3.0	1.8	5.4	5.2	9.3
Going to school	3.0	0.3	5.3	1.5	0.4	0.3	0.2	-

*Excludes persons whose usual activity was unknown.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

TABLE 11. *Labor force and current employment status of diabetics and the general population age 20 years and older, United States, 1979-81*

Labor Force and Employment Status*	Age (Years)							
	20 and over		20-44		45-64		65 and over	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Number (thousands)	148,995	5,337	81,243	809	43,725	2,406	24,027	2,123
Percent in labor force	65.3	35.6	80.2	66.6	65.7	47.3	14.3	10.4
Percent employed of those in labor force	94.0	94.9	93.0	91.9	96.1	96.6	96.0	93.9
Men								
Number (thousands)	70,108	2,314	39,386	328	20,847	1,146	9,874	840
Percent in labor force	79.5	49.7	92.9	83.4	81.7	64.1	21.5	16.6
Percent employed of those in labor force	94.7	96.3	93.8	93.2	96.5	97.2	96.4	97.2
Women								
Number (thousands)	78,886	3,023	41,856	481	22,878	1,259	14,153	1,283
Percent in labor force	52.7	24.8	68.2	55.0	51.2	32.0	9.3	6.4
Percent employed of those in labor force	93.1	92.9	92.0	90.5	95.5	95.4	95.2	88.3

*The labor force consists of persons currently employed at least during the 2 weeks prior to the week of interview during the survey, and persons currently unemployed but looking for work or on layoff from work.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

In 1979-81 about one-half of diabetic men and one-fourth of diabetic women were actively involved in the work force on a regular basis. This proportion was higher among younger diabetics, declining with age, and men were much more likely to be in the work force than women were, as in the general population (Figure 7). Other indicators of work force participation, which take into account a person's experience over a 12-month period, show comparable estimates (Krall et al. 1985). For example, in 1977 about 30 percent of diabetics 20 years and over had year-round work experience, i.e., had worked at a job or business during all 12 months of the preceding year; as many as 20 percent may have worked at a job or business for at least 1 of the past 12 months. Black diabetics have lower rates of participation than do white diabetics, and those with fewer years of educational attainment have lower rates of participation than do those with more years (Krall et al. 1985). Diabetics with limitations on activity because of their diabetes or some other chronic condition or impairment are less likely to participate in the work force than those without such limitations.

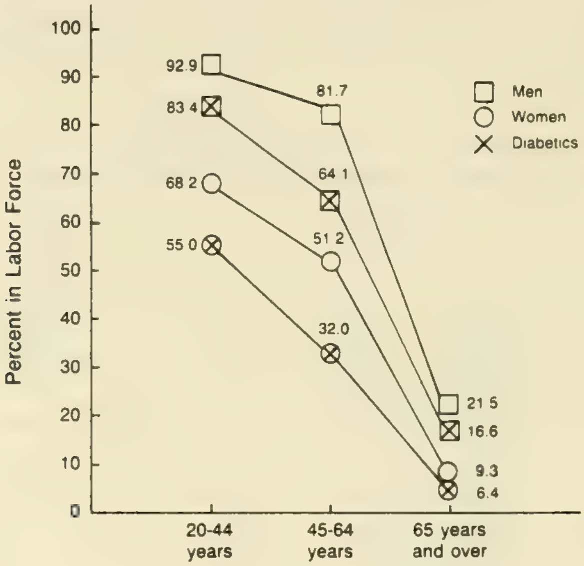

FIGURE 7. *Labor force participation rates of persons 20 years of age and over by diabetic status, sex, and age, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Occupation

The occupational profile of currently employed diabetics is quite similar to that of the general employed population (Table 12). In 1979-81, 52.1 percent of employed diabetics were in white-collar occupations; 30.9 percent were in blue-collar jobs, 19.3 percent were in service jobs, and 2.9 percent were farm workers. Among employed diabetics and the general population, the occupational distribution differs for men and women, with a greater proportion of women in white-collar and service jobs, and a greater proportion of men in blue-collar and farm jobs. For persons age 20 years and over, the proportion of diabetic men in white-collar, service, and farm jobs was similar to that of the general population, but was lower in blue-collar jobs; diabetic women compared to the general population of women were more frequently employed in service jobs and less often in white-collar occupations. The occupations of employed diabetics differed from those of the general population of employed persons in three important ways: 1) elderly diabetic men were proportionately more likely to

TABLE 12. *Occupation of currently employed diabetics and the general population age 20 years and older, by age and sex, United States, 1979-81**

	Both Sexes		Men		Women	
Occupation and Age (Years)	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
20-44						
Number (thousands)	59,854	499	33,905	258	25,949	241
			Percent Distribution			
White collar	57.1	57.0	45.0	49.4	72.9	65.2
Professional, technical, and kindred workers	19.7	18.7	18.0	17.1	21.8	20.4
Managers and administrators, except farm	11.8	13.3	14.6	17.6	8.2	8.8
Sales workers	6.1	6.4	5.8	7.3	6.5	5.5
Clerical and kindred workers	19.4	18.6	6.5	7.5	36.3	30.5
Blue collar	36.0	31.7	50.9	43.8	16.5	18.8
Craftspeople and kindred workers	15.0	10.4	24.4	18.6	2.8	1.6
Operatives, except transport	12.3	13.7	13.0	15.5	11.4	11.7
Transport equipment operatives	4.0	3.0	6.4	4.3	0.9	1.6
Laborers, except farm	4.6	4.6	7.1	5.4	1.3	3.8
Service	12.3	18.9	7.8	13.3	18.1	24.9
Service workers, except private households	11.7	16.7	7.8	13.3	17.0	20.3
Private household workers	0.5	2.2	0.0	0.0	1.1	4.6
Farm	1.8	0.8	2.6	0.8	0.8	0.8
Farmers and farm managers	0.9	0.8	1.4	0.8	0.2	0.8
Farm laborers and foremen	0.9	0.0	1.2	0.0	0.6	0.0
45-64						
Number (thousands)	27,327	1,097	16,253	712	11,075	385
			Percent Distribution			
White collar	56.0	49.8	49.2	48.0	66.0	53.2
Professional, technical, and kindred workers	16.4	12.4	16.3	13.7	16.5	9.9
Managers and administrators, except farm	16.0	15.3	20.2	18.2	10.0	10.1
Sales workers	7.0	6.2	6.5	7.3	7.6	4.2
Clerical and kindred workers	16.6	15.9	6.2	8.8	31.9	29.0
Blue collar	32.6	32.1	43.2	40.4	16.9	16.7
Craftspeople and kindred workers	14.8	14.3	23.1	20.6	2.6	2.5
Operatives, except transport	11.0	11.3	9.8	10.3	12.9	13.1
Transport equipment operatives	3.7	3.5	5.7	5.0	0.6	0.7
Laborers, except farm	3.1	3.1	4.6	4.5	0.9	0.5
Service	12.5	18.1	7.1	10.3	20.4	32.5
Service workers, except private household	11.2	15.8	7.0	10.3	17.3	25.9
Private household workers	1.3	2.3	0.1	0.0	3.1	6.6
Farm	2.9	3.4	4.1	4.2	1.2	1.9
Farmers and farm managers	2.1	2.6	3.2	3.6	0.4	0.9
Farm laborers and foremen	0.8	0.8	0.9	0.6	0.7	1.0

(Continued)

TABLE 12. (Continued)

	Both Sexes		Men		Women	
Occupation and Age (Years)	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
65 and over						
Number (thousands)	3,254	202	2,018	131	1,236	71
			Percent Distribution			
White Collar	52.4	52.0	48.6	60.0	58.6	37.2
Professional, technical, and kindred workers	14.6	10.4	15.0	14.0	14.0	3.7
Managers and administrators, except farm	14.6	15.8	16.9	20.7	10.8	6.6
Sales workers	11.3	17.4	10.3	19.7	13.0	13.3
Clerical and kindred workers	11.9	8.4	6.4	5.6	20.8	13.7
Blue Collar	23.4	22.9	29.7	23.7	13.0	21.2
Craftspeople and kindred workers	11.0	10.9	15.9	15.2	2.8	2.9
Operatives, except transport	6.5	8.3	4.8	2.9	9.3	18.4
Transport equipment operatives	2.5	2.8	3.9	4.4	0.3	0.0
Laborers, except farm	3.4	0.9	5.0	1.3	0.7	0.0
Service	19.8	26.4	13.1	12.5	30.9	52.4
Service workers, except private household	15.7	20.8	12.9	12.5	20.3	36.2
Private household workers	4.1	5.7	0.2	0.0	10.5	16.2
Farm	8.6	5.4	12.4	6.8	2.5	2.8
Farmers and farm managers	6.7	4.4	10.0	6.8	1.3	0.0
Farm laborers and foremen	1.9	1.0	2.4	0.0	1.1	2.8

*Excludes currently employed persons whose occupation was unknown.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

be in white-collar jobs than elderly men generally were; 2) diabetic men under age 65, particularly those 20-44 years of age, were less likely to be in blue-collar jobs and more likely to be in service jobs than their nondiabetic counterparts; and 3) irrespective of age (but particularly among the elderly), diabetic women were less likely to be in white-collar jobs and more likely to be service workers.

Since most diabetes is diagnosed long after people have settled into an occupation, it is reasonable to assume that the forces shaping the occupational distribution of diabetic men and women are largely similar to those affecting the occupational distribution generally. However, the recent expanding array of white-collar occupations may offer a more adequate person-job match for some diabetics, particularly those diagnosed early. Indeed, men and women diagnosed before their twentieth birthday differ with respect to occupational group from diabetics diagnosed at later ages (Table 13). Early-diagnosed women are more likely to be in white-collar jobs than are women diagnosed at older ages. Men diagnosed before their twentieth birthday, however, were more likely to be in blue-collar jobs than men diagnosed as diabetic at later ages. This latter finding for men occurs among both younger and older cohorts of early-diagnosed diabetics (data not shown).

TABLE 13. *Percent distribution of currently employed diabetics 20 years of age and older by occupational group, age at time of diagnosis, and sex, United States, 1976*

Sex and Occupational Group	Age (Years) at Time of Diagnosis of Diabetes					
	All Ages	Under 20	20-39	40-49	50-59	60+
Men						
White collar	45.4	33.2	48.1	45.0	46.3	43.4
Blue collar	40.9	60.6	44.9	40.0	37.7	34.8
Service	9.1	3.2	5.2	11.4	10.3	11.5
Farm	4.1	2.9	1.7	2.8	4.9	10.3
Women						
White collar	52.3	65.9*	49.0	56.0	50.7	49.1
Blue collar	20.2	13.4*	23.7	18.2	22.6	8.1*
Service	25.0	16.5*	26.5	21.4	23.4	42.7*
Farm	1.7	-	-	4.5	3.3	-

*Relative standard error greater than 30 percent.

SOURCE: Krall, LP, PS Entmacher, and TF Drury. Life cycle in diabetics--sociodemographic aspects. In: Joslin's Diabetes Mellitus, 12th edition. Marble, A, et al., eds. Philadelphia: Lea & Febiger, 1985.

Industry

In 1979-81, currently employed diabetics were found primarily in service industries (34.0 percent), manufacturing (23.2 percent), and wholesale and retail settings (18.1 percent) (Appendix G). The remainder were in public administration (8.5 percent), transportation and public utilities (6.3 percent), construction industries (5.3 percent), finance/insurance/real estate (5.1 percent), and agriculture (3.7 percent). While the same occupation can occur in many different industries, industries do vary with respect to their occupational composition. Partly for this reason, some of the differences already noted among women between diabetics and the general population with respect to their occupational distribution are also reflected in the proportions of diabetics in various industrial settings. This is particularly the case with respect to the proportion of diabetic women in service jobs and related miscellaneous industrial settings.

Class of Worker Status

The vast majority (74.6 percent) of employed diabetics were in privately paid jobs in 1979-81 (Appendix H). Almost 1 in 5 (19.1 percent) worked for government at either local, State, or Federal levels. About 1 in 10 (11.0 percent) was self-employed.

Veteran Status of Diabetic Men

Diabetes is a medical condition that precludes military service and is likely to lead to discharge if it occurs while a person is in military service. Nonetheless, diabetic men are just as likely to have been in the armed services some time in the past as the general population has (Appendix I). This particular aspect of the backgrounds of diabetic men probably reflects a number of different phenomena. First, the vast majority of diabetics are diagnosed in their middle or later years, and probably these men had completed their tour of military service long before their diabetes was diagnosed. The age-specific data on veteran status among adult men may also reflect cohort and period differences in military conscription. Among the youngest men (20 to 44 years of age), diabetics are less likely than the general population to have served in the armed forces. Among men in their middle and later years, however, diabetics are just about as likely to be veterans as men in these older age groups generally.

FAMILY INCOME

In view of their rates of participation in the work force, educational attainment levels, and household composition, it would be surprising if adult diabetics did not also differ from the general population with respect to family income. In 1981, 15.9 percent of the general population 20 years and over in contrast with 29.4 percent of adult diabetics were living in families with less than $7,000 annual income (Table 14, Figure 8). On the other hand, about 35.9 percent of the general population lived in families with annual incomes of $25,000 or more while only about 23.4 percent of diabetics were so situated. Among diabetics, women were more likely (37.4 percent) than men (19.5 percent) to live in families with incomes below $7,000 a year. This income difference between men and women increased with age and existed for both diabetics and the general population, but was more prominent for diabetics. Being in a very low-income family was much more likely for older persons than it was for younger persons. Accordingly, when incomes of older persons are examined, there was

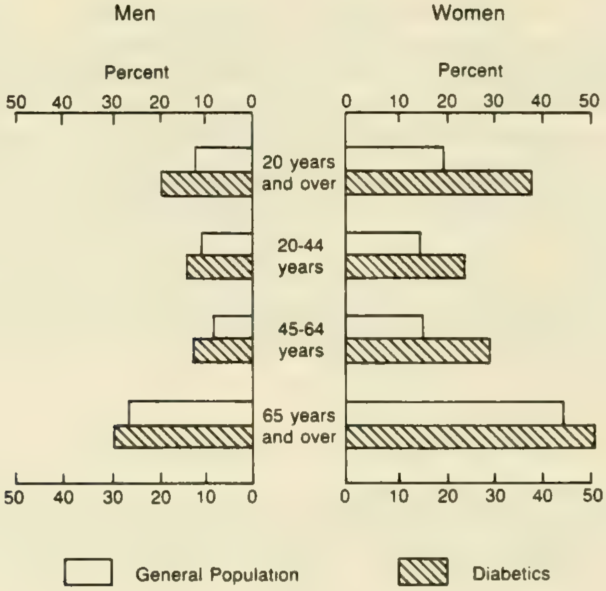

FIGURE 8. *Percent of persons 20 years and over living in families with less than $7,000 annual income by diabetic status, age and sex, United States, 1981*

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1981 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

either no difference (as was the case for men) or less difference (as was the case for women) between diabetics age 65 years and over and the general population in that age range. This does not mean that adult diabetics are not in fact poorer as a group than the general population age 20 years and over. It simply means that the low income of elderly adult diabetics may be partially due to age-related differences in family income patterns, including exiting from the labor market. Young and middle-aged diabetic women were more likely than their counterparts in the general population to be in a low-income family.

TABLE 14. *Family income of diabetics and the general population age 20 years and older, United States, 1981**

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
Family Income	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Number (thousands)	138,690	4,916	78,547	789	39,001	2,179	21,142	1,947
				Percent Distribution				
Under $3,000	3.3	5.9	3.4	6.9	2.4	4.9	4.7	6.7
$3,000-$4,999	5.8	12.5	4.0	6.1	4.1	8.8	15.6	19.2
$5,000-$6,999	6.7	11.0	5.0	5.7	5.1	7.8	16.0	16.7
$7,000-$9,999	8.6	11.9	7.0	8.7	7.2	11.6	17.2	13.5
$10,000-$14,999	15.1	16.3	14.8	7.4	14.1	18.2	18.1	17.7
$15,000-$24,999	24.5	19.0	27.5	28.5	24.1	19.1	14.4	15.1
$25,000 or more	35.9	23.4	38.3	36.8	42.8	29.5	14.0	11.1
Men								
Number (thousands)	65,552	2,190	38,190	399	18,617	1,021	8,745	770
				Percent Distribution				
Under $3,000	2.7	4.0	3.1	5.1	1.9	4.3	2.6	3.1
$3,000-$4,999	4.1	7.8	3.4	3.1	2.9	6.6	10.0	11.9
$5,000-$6,999	5.8	7.7	4.5	6.3	4.2	2.8	14.6	14.9
$7,000-$9,999	8.0	9.6	6.6	6.3	5.8	9.4	18.7	11.6
$10,000-$14,999	14.8	18.3	14.4	7.2	12.7	17.5	20.9	25.1
$15,000-$24,999	25.9	23.3	28.5	31.1	24.7	23.5	16.9	18.9
$25,000 or more	38.8	29.3	39.6	40.8	47.8	36.0	16.3	14.4
Women								
Number (thousands)	73,138	2,726	40,357	390	20,384	1,158	12,396	1,177
				Percent Distribution				
Under $3,000	3.9	7.5	3.7	8.8	3.0	5.5	6.1	9.1
$3,000-$4,999	7.3	16.2	4.6	9.1	5.2	10.8	19.6	24.0
$5,000-$6,999	7.6	13.6	5.5	5.0	6.0	12.3	17.1	17.9
$7,000-$9,999	9.2	13.7	7.4	11.2	8.6	13.6	16.2	14.7
$10,000-$14,999	15.4	14.7	15.2	7.5	15.4	18.8	16.1	13.0
$15,000-$24,999	23.3	15.6	26.5	25.7	23.5	15.3	12.6	12.5
$25,000 or more	33.2	18.6	37.1	32.7	38.4	23.8	12.3	8.9

*Excludes persons whose family income was unknown.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1981 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

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APPENDIX A. *Median age (years) of persons 20 years and older by diabetic status, sex, and race, United States, 1979-81*

	Both Sexes		Men		Women	
Race	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All races	42	61	41	60	43	61
White	42	61	42	61	43	62
All other races	38	58	39	56	38	59
Black	39	58	39	55	39	59

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX B. *Number and percent distribution by sex of diabetics and the general population age 20 years and older, United States, 1979-81*

Age (Years) and Race	General Population			Diabetics		
	Both Sexes (Thousands of Persons)	Percent Distribution		Both Sexes (Thousands of Persons)	Percent Distribution	
		Men	Women		Men	Women
All races						
All ages	148,995	47.1	52.9	5,337	43.3	56.7
20-24	20,141	48.4	51.6	76	37.7	62.3
25-29	18,625	48.7	51.3	124	43.7	56.3
30-34	17,068	48.7	51.3	168	39.4	60.6
35-39	13,747	47.8	52.2	200	37.0	63.0
40-44	11,661	48.7	51.3	241	44.6	55.4
45-49	11,007	48.5	51.5	403	48.8	51.3
50-54	11,566	48.1	51.9	563	46.2	53.8
55-59	11,227	47.2	52.8	719	46.9	53.1
60-64	9,925	46.8	53.2	725	48.5	51.5
65-69	8,689	44.0	56.0	730	44.3	55.7
70-74	6,561	42.7	57.3	608	42.4	57.6
75-79	4,503	38.6	61.4	492	35.9	64.1
80+	4,275	35.2	64.8	293	27.9	72.1
Whites						
All ages	131,086	47.4	52.6	4,429	44.4	55.6
20-34	48,116	49.2	50.8	307	38.9	61.1
35-49	31,838	48.8	51.2	655	45.6	54.4
50-64	29,326	47.6	52.4	1,628	48.8	51.2
65-79	17,866	42.4	57.6	1,580	42.9	57.1
80+	3,940	34.8	65.2	259	29.8	70.2
Blacks						
All ages	15,286	44.1	55.9	825	37.0	63.0
20-34	6,490	44.5	55.5	57	45.1	54.9
35-49	3,840	44.4	55.6	174	41.8	58.2
50-64	2,937	45.2	54.8	332	39.2	60.8
65-79	1,714	41.4	58.6	228	31.5	68.5
80+	304	38.5	61.5	34	13.4	86.6

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX C. *Sex ratio (number of men per 100 women) of persons 20 years and older by diabetic status, age, and race, United States, 1979-81*

Age (Years)	All Races		White		Black	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
20+	88.9	76.5	90.1	79.9	79.0	58.7
20-34	94.5	68.0	96.9	63.5	80.2	82.1
35-49	93.5	81.1	95.2	83.9	79.9	71.9
50-64	90.1	89.8	90.9	95.4	82.4	64.5
65-79	73.5	70.7	73.6	75.1	70.7	46.0
80+	54.4	38.7	53.5	42.4	62.5	15.5

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX D. *Number and percent distribution by race of diabetics and the general population age 20 years and older, United States, 1979-81*

Age (Years) and Sex	General Population			Diabetics		
	All Races (Thousands of Persons)	Percent of Persons		All Races (Thousands of Persons)	Percent of Persons	
		White	Black		White	Black
Both sexes						
All ages	148,995	88.0	10.3	5,337	83.1	15.4
20-24	20,144	85.5	12.5	76	85.6	14.5
25-29	18,625	86.1	11.7	124	90.5	9.5
30-34	17,068	87.1	10.6	168	78.4	19.2
35-39	13,747	87.4	10.4	200	80.0	20.0
40-44	11,661	87.3	10.8	241	74.8	24.2
45-49	11,007	87.6	10.5	403	78.1	18.7
50-54	11,566	88.7	9.7	563	76.5	20.8
55-59	11,227	90.0	8.8	720	81.2	16.4
60-64	9,925	90.4	8.4	719	85.3	13.4
65-69	8,689	90.0	9.0	730	85.0	13.2
70-74	6,561	90.7	8.4	608	86.8	12.4
75-79	4,503	91.0	8.5	492	87.9	11.4
80+	4,275	92.2	7.1	293	88.6	11.4
Men						
All ages	70,108	88.6	9.6	2,314	85.1	13.1
20-34	27,130	87.3	10.6	147	80.5	16.7
35-49	17,594	88.3	9.7	379	79.1	19.2
50-64	15,510	90.0	8.6	949	84.0	13.7
65-79	8,369	90.5	8.5	758	89.4	9.5
80+	1,506	91.2	7.8	82	94.5	5.5
Women						
All ages	78,886	87.4	10.8	3,023	81.5	17.1
20-34	28,705	85.1	12.5	221	86.2	13.8
35-49	18,822	86.6	11.3	465	76.4	21.7
50-64	17,208	89.3	9.4	1,054	79.0	19.1
65-79	11,384	90.4	8.8	1,073	84.2	14.6
80+	2,769	92.7	6.8	210	86.3	13.7

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX E. *Number and percent distribution by region and location of residence of diabetics and the general population age 20 years and older, United States, 1979-81*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
General Location of Residence	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Number (thousands)	148,995	5,337	81,243	809	43,725	2,406	24,027	2,123
				Percent Distribution				
Northeast	22.5	22.4	21.5	20.9	23.7	22.3	23.9	23.2
Within SMSA	18.0	17.8	17.2	15.9	19.3	18.7	18.6	17.5
Central city	7.0	8.5	6.7	7.1	7.1	9.2	8.2	8.2
Outside central city	11.0	9.3	10.5	8.8	12.2	9.5	10.4	9.3
Outside SMSA	4.5	4.7	4.3	5.0	4.4	3.7	5.3	5.7
Nonfarm	4.3	4.4	4.2	4.7	4.3	3.4	5.1	5.4
Farm	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.3
North Central	26.3	26.1	26.6	28.1	26.0	26.0	25.7	25.4
Within SMSA	17.5	17.2	18.2	18.7	17.3	18.3	15.3	15.4
Central city	6.9	7.3	7.0	7.0	6.6	7.9	7.4	6.8
Outside central city	10.5	9.9	11.2	11.7	10.8	10.4	8.0	8.6
Outside SMSA	8.8	8.9	8.5	9.4	8.7	7.7	10.4	10.0
Nonfarm	7.7	8.0	7.6	9.4	7.1	6.8	9.0	8.7
Farm	1.2	0.9	0.9	0.0	1.5	0.9	1.4	1.3
South	32.4	36.2	32.2	33.2	32.3	37.8	33.0	35.6
Within SMSA	18.6	19.4	19.2	19.1	18.2	20.8	17.0	17.9
Central city	8.5	9.8	8.5	10.3	8.3	10.5	8.6	8.8
Outside central city	10.1	9.6	10.8	8.8	9.9	10.3	8.3	9.1
Outside SMSA	13.8	16.9	13.0	14.1	14.1	17.0	16.1	17.7
Nonfarm	12.8	15.7	12.2	13.7	12.8	15.9	14.7	16.1
Farm	1.0	1.2	0.8	0.4	1.3	1.1	1.4	1.6
West	18.8	15.2	19.6	17.7	18.0	13.8	17.4	15.8
Within SMSA	14.7	11.9	15.5	14.4	14.0	11.2	13.3	11.8
Central city	5.8	5.4	6.1	6.7	5.4	5.1	5.5	5.3
Outside central city	8.9	6.5	9.4	7.7	8.6	6.1	7.9	6.5
Outside SMSA	4.1	3.3	4.1	3.3	4.1	2.6	4.1	4.0
Nonfarm	3.8	3.1	3.8	3.1	3.7	2.4	3.8	3.9
Farm	0.3	0.2	0.3	0.3	0.4	0.2	0.3	0.2

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX F. *Geographic distribution by sex of diabetics and the general population age 20 years and older, United States, 1979-81*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
General Geographic Area	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Men								
Number (thousands)	70,108	2,314	39,386	328	20,847	1,146	9,874	840
	Percent Distribution							
Region								
Northeast	22.2	23.4	21.2	22.6	23.4	25.0	23.8	21.6
North Central	26.5	26.4	27.0	29.7	26.1	27.4	25.1	23.6
South	32.3	33.8	32.1	29.3	32.2	33.1	33.2	36.4
West	19.0	16.4	19.7	18.3	18.3	14.5	17.9	18.3
Location of residence								
Within SMSA	68.6	69.6	69.8	73.4	68.9	72.3	62.8	64.6
Central city	27.6	31.8	28.0	34.3	26.7	32.6	27.9	29.7
Outside central city	41.0	37.9	41.9	39.1	42.2	39.7	34.9	34.9
Outside SMSA	31.4	30.4	30.2	26.6	31.1	27.7	37.2	35.4
Nonfarm	28.6	27.5	27.9	26.1	27.5	25.2	33.3	31.2
Farm	2.9	2.8	2.3	1.0	3.6	2.5	3.9	4.2
Size of place (population)*								
Within SMSA								
Less than 250,000	8.5	8.2	8.9	10.5	8.2	7.5	7.7	8.1
250,000-499,999	9.5	10.6	10.0	7.8	9.0	11.7	9.1	10.2
500,000-999,999	10.7	11.1	10.7	8.2	11.3	13.3	9.8	9.0
1 up to 3 million	21.7	21.7	22.5	26.0	21.5	23.0	19.1	17.4
3 million or more	18.7	18.8	19.0	21.9	19.0	17.2	17.2	19.8
Outside SMSA								
Rural area	19.3	18.2	18.0	14.9	19.8	17.1	23.5	21.8
Urban area	11.4	11.4	11.0	10.6	11.3	10.1	13.7	13.8

(Continued)

APPENDIX F. (Continued)

General Geographic Area	Age (Years) 20 and over General Population	20 and over Diabetics	20-44 General Population	20-44 Diabetics	45-64 General Population	45-64 Diabetics	65 and over General Population	65 and over Diabetics
Women								
Number (thousands)	78,886	3,023	41,856	481	22,878	1,259	14,153	1,283
				Percent Distribution				
Region								
Northeast	22.8	21.7	21.7	19.7	24.0	19.9	23.9	24.1
North Central	26.1	25.9	26.3	27.0	25.8	24.8	26.2	26.6
South	32.5	38.1	32.4	35.9	32.3	42.1	32.9	35.1
West	18.6	14.3	19.6	17.3	17.8	13.2	17.1	14.2
Location of residence								
Within SMSA	69.0	63.8	70.4	64.6	68.7	66.0	65.2	61.3
Central city	28.9	30.5	28.6	29.0	28.0	32.9	30.9	28.7
Outside central city	40.1	33.3	41.7	35.5	40.7	33.1	34.4	32.6
Outside SMSA	31.0	36.2	29.6	35.4	31.3	34.0	34.8	38.7
Nonfarm	28.6	33.9	27.7	34.1	28.2	31.7	31.9	36.0
Farm	2.5	2.3	1.9	1.3	3.2	2.3	2.8	2.7
Size of place (population)*								
Within SMSA								
Less than 250,000	8.5	8.8	8.9	10.1	8.4	8.4	7.5	8.7
250,000-499,999	9.5	9.7	10.1	12.1	8.9	9.1	9.0	9.3
500,000-999,999	10.8	9.6	11.2	9.9	10.8	9.0	9.5	10.0
1 up to 3 million	21.7	20.2	22.4	21.8	21.3	20.6	20.1	19.3
3 million or more	18.9	18.3	18.7	19.3	19.5	18.5	18.8	17.7
Outside SMSA								
Rural area	18.1	19.5	16.9	16.0	19.2	21.0	19.5	19.6
Urban area	12.5	13.8	11.8	10.8	11.9	13.4	15.5	15.4

*Data are for the year 1973.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX G. *Industry of currently employed diabetics and the general population age 20 years and older, United States, 1979-81**

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
Industry	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Number (thousands)	90,482	1,794	59,893	499	27,332	1,095	3,256	200
				Percent Distribution				
Services and miscellaneous	30.7	34.0	30.9	36.9	29.1	30.9	39.4	43.7
Manufacturing	25.3	23.2	25.7	26.6	25.8	22.7	12.4	17.2
Wholesale, retail	18.8	18.1	19.3	19.7	17.1	17.1	22.3	19.4
Transportation, public utilities	7.1	6.3	7.2	3.9	7.3	8.3	2.9	1.8
Construction	6.9	5.3	7.3	4.7	6.2	5.5	5.4	6.0
Public administration	6.6	8.5	6.3	8.0	7.6	9.9	4.3	2.8
Finance, insurance, real estate	6.3	5.1	6.3	5.1	6.2	4.4	7.1	8.8
Agriculture	3.0	3.7	2.4	2.4	3.5	3.9	9.8	6.4
Mining	1.2	0.8	1.3	1.1	1.0	0.7	0.5	0.7
Forestry, fisheries	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.0
Men								
Number (thousands)	52,223	1,100	33,934	258	16,269	710	2,021	131
				Percent Distribution				
Services and miscellaneous	20.3	21.9	20.5	22.3	18.7	20.1	30.0	30.7
Manufacturing	29.6	27.6	30.3	34.7	30.2	26.5	14.0	19.7
Wholesale, retail	17.0	15.4	17.8	17.1	14.8	14.9	20.6	15.0
Transportation, public utilities	9.2	9.2	9.2	6.8	9.8	11.3	4.0	2.7
Construction	11.0	8.3	11.8	8.4	9.7	8.2	8.3	9.1
Public administration	7.3	10.0	6.8	8.6	8.6	11.9	4.4	2.9
Finance, insurance, real estate	4.7	5.7	4.3	5.5	5.2	4.4	7.6	13.4
Agriculture	4.2	4.5	3.3	2.5	4.7	4.5	13.9	8.3
Mining	1.8	1.0	2.0	1.4	1.6	0.8	0.8	1.1
Forestry, fisheries	0.2	0.0	0.2	0.0	0.2	0.0	0.1	0.0
Women								
Number (thousands)	38,259	695	25,960	241	11,064	385	1,235	68
				Percent Distribution				
Services and miscellaneous	44.8	53.1	44.5	52.6	44.5	50.7	54.8	68.5
Manufacturing	19.3	16.2	19.7	17.9	19.3	15.8	9.7	12.3
Wholesale, retail	21.2	22.3	21.4	22.6	20.4	21.0	25.1	27.9
Transportation, public utilities	4.2	1.7	4.7	0.8	3.6	2.6	1.0	0.0
Construction	1.3	0.6	1.5	0.8	1.1	0.7	0.8	0.0
Public administration	5.8	6.2	5.7	7.3	6.2	6.1	4.2	2.4
Finance, insurance, real estate	8.5	4.0	9.0	4.6	7.6	4.3	6.2	0.0
Agriculture	1.4	2.6	1.3	2.4	1.6	2.6	3.0	2.8
Mining	0.4	0.5	0.4	0.7	0.2	0.5	0.1	0.0
Forestry, fisheries	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0

*Excludes currently employed persons whose industry was unknown.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX H. *Class of worker of currently employed diabetics and the general population age 20 years and older, United States, 1979-81**

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
Class of Worker	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Number (thousands)	90,511	1,798	59,918	499	27,334	1,097	3,259	202
				Percent Distribution				
Private paid	79.0	74.6	82.7	84.5	72.4	70.7	65.1	71.1
Federal government	3.8	5.5	3.5	5.6	4.7	6.1	2.0	2.2
State government	4.2	3.9	4.4	4.6	4.1	3.8	2.2	2.5
Local government	9.4	9.7	9.1	7.3	10.4	11.8	6.8	4.0
Self-employed	9.0	11.0	6.9	6.4	11.7	10.6	26.6	24.9
Non-paid	0.6	0.3	0.5	0.0	0.8	0.2	1.5	2.0
New worker	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Men								
Number (thousands)	52,305	1,106	34,003	260	16,278	713	2,024	133
				Percent Distribution				
Private paid	79.1	71.9	83.5	85.6	72.0	67.6	60.3	68.0
Federal government	4.1	6.9	3.6	4.8	5.5	8.4	1.7	3.3
State government	3.6	3.7	3.7	6.3	3.6	3.0	1.8	2.5
Local government	7.1	9.0	6.9	6.5	7.8	11.3	6.0	2.0
Self-employed	11.3	12.2	8.4	4.1	14.6	12.3	32.9	27.1
Non-paid	0.1	0.2	0.1	0.0	0.1	0.3	0.4	0.0
New worker	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Women								
Number (thousands)	38,206	691	25,915	239	11,055	383	1,235	69
				Percent Distribution				
Private paid	78.8	78.9	81.7	83.4	72.8	76.5	72.8	77.1
Federal government	3.4	3.3	3.4	6.4	3.6	1.9	2.5	0.0
State government	5.0	4.1	5.2	2.9	4.8	5.2	2.8	2.4
Local government	12.5	10.7	12.0	8.1	14.2	12.9	8.2	7.9
Self-employed	6.0	9.2	4.9	8.9	7.4	7.3	16.2	20.6
Non-paid	1.3	0.6	1.1	0.0	1.8	0.0	2.5	5.8
New worker	0.1	0.0	0.2	0.0	0.0	0.0	0.1	0.0

*Excludes currently employed persons whose class of worker status was unknown.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX I. *Percent who are veterans among diabetic men and the general male population age 20 years and older, United States, 1979-81**

Age (Years)							
20 and over		20-44		45-64		65 and over	
General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
40.6	44.0	29.3	19.6	67.9	66.2	28.1	23.8

*Excludes men whose veteran status was unknown.

SOURCE: National Center for Health Statistics. Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

CHAPTER VIII. DIABETES IN BLACK AMERICANS

Jeffrey M. Roseman, M.D., Ph.D., M.P.H.

SUMMARY

Studies of the descriptive epidemiology of diabetes in blacks in the United States indicate temporal, geographic, and sex variation in the prevalence of diabetes and its complications. Currently, approximately 3.2 percent of blacks in the United States have been diagnosed as having diabetes, and about 4.4 percent between ages 20 and 74 years may have undiagnosed diabetes. The majority appear to have noninsulin-dependent diabetes mellitus (NIDDM). There has been a considerable increase since the turn of the century in prevalence and mortality rate of diabetes in United States blacks. During this period, both the black:white ratio and the black female:black male ratio have shifted from less than 1 to greater than 1. The prevalence of diabetes among blacks is currently greater than among whites. Although comparative data from Africa is scarce and of uncertain validity, the prevalence of diabetes among United States blacks appears to be greater than among African blacks, except perhaps in urban areas.

It is hazardous to use the available estimates of the prevalence of diabetes in black children and young adults to estimate the prevalence of insulin-dependent diabetes mellitus (IDDM). However, the prevalence of IDDM in blacks in the United States is probably less than in whites and greater than in African blacks. How much of a prevalence differential there is between United States whites and blacks is uncertain. Estimates have ranged as high as 5 to 1, although incidence studies suggest a ratio of 2 to 1, or less.

Macrovascular disease, retinopathy, renal disease, and peripheral vascular disease, as with whites, occur more frequently among blacks with diabetes than among those without. Although there are only a few studies, it appears that in the United States blacks with diabetes have a greater risk for diabetic complications than do whites with diabetes.

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INTRODUCTION

There are currently about 27 million black Americans, constituting about 12 percent of the United States population (Bureau of the Census 1981). Blacks have been an important American subpopulation since they were first brought involuntarily to the Jamestown settlement in 1619. During the major period of slave importation, from 1700 to 1808, about 400,000 blacks entered the United States, almost all from the area of West and West-Central Africa, predominantly from the present countries of Nigeria and Angola (Reed 1969). Through admixture with the white population, blacks now have an average of 20 percent white genes, with population estimates of admixture ranging from 3.6 percent to 26 percent, depending on the area of the United States. Because United States blacks are a population that has undergone both migration and genetic admixture, their comparison with United States whites and African blacks can be useful in generating hypotheses concerning the etiology and natural history of diabetes.

DIFFERENTIATION OF IDDM AND NIDDM IN BLACKS

Most of the studies on diabetes in black Americans were conducted prior to the criteria established by the National Diabetes Data Group (NDDG 1979) differentiating diabetes into NIDDM and IDDM. Since the vast majority of adults with diabetes in the United States appear to be NIDDMs, studies on diabetes prevalence in adults may provide a good estimate of the prevalence of NIDDM. Consequently, in this chapter studies on adults have been used to assess NIDDM in blacks.

Few studies have specifically identified IDDM cases in blacks or provided information on insulin use, ketosis proneness, and weight, which could be used to define IDDM. A compromise in estimating IDDM prevalence in blacks is to examine the prevalence of diabetes in children and young adults. However, there are problems with using these age groups to estimate IDDM prevalence. First, IDDM can occur at any age, and second, it is probable that IDDM cases make up a smaller proportion of young blacks with diabetes than young whites with diabetes. This conclusion is based on the finding that white children were more likely to present with the signs of IDDM, such as polyuria, polydipsia, and ketonuria, and black children were more likely to present with obesity or to be asymptomatic (MacDonald 1980).

PREVALENCE OF DIAGNOSED DIABETES IN BLACK ADULTS

Military Populations

Population studies with sufficient numbers to reliably assess the prevalence of diabetes in adult blacks in the United States are summarized in Table 1. The first national estimates come from data collected by the United States Army on diabetes among men drafted during World War I. Among this group, ages 18-45 years, the prevalence was 0.13/1,000 for "agricultural, negro, 45 percent plus." For comparison, the rate for "agricultural, native white, South" was 0.15/1,000; for "agricultural, native white, North" it was 0.45/1,000 (Emerson and Larimore 1924). By World War II, the prevalence among black male military registrants was 1.9/1,000 in one report and 0.8/1,000 in another report (Table 1). Both of these were less than the estimate of 3.0/1,000 for white males.

TABLE 1. *Population-based studies on the prevalence of diabetes in United States black adults*

Reference	Year	Age (Years)	Percent Diabetic*			Comments
			Male	Female	Both	
U.S. Military Draftees or Registrants						
a	1924	18-45	0.015	-	-	Black male WW I draftees rate much lower than white male rate
b	1943	18-45	0.19	-	-	Black male WW II military registrants rate less than white male rate
c	1944	18-45	0.08	-	-	Black male WW II military registrants rate less than white male rate
National Health Surveys of the U.S. Population						
d	1960-62	18-79				Black men had slightly but significantly higher blood glucose values. Black women had poorer GTT but not when stratified on education.
e	1963	All			1.17	Black/white = 1.0
e	1964	All			1.27	Black/white = 1.0
f	1964-65	All	0.84	1.78	1.38	Black/white = 1.1
		<45	0.24	0.31	0.28	
		45+	2.96	6.86	5.02	
e	1965	All			1.38	Black/white = 1.1
e	1966	All			1.46	Black/white = 1.0
e	1967	All			1.69	Black/white = 1.1
e	1968	All			1.70	Black/white = 1.0
e	1973	All			2.47	Black/white = 1.2
e	1975	All	2.18	3.50	2.89	Black/white = 1.3
		17-44			1.44	
		45-64			8.72	
		65+			11.44	
e	1976	All	2.26	3.30	2.82	Black/white = 1.2
e	1978	All	2.09	3.61	2.91	Black male/white male = 1.0; Black female/white female = 1.3
		15-44	0.63	1.12	0.90	
		45-64	5.4	10.8	8.3	
		65-84	12.9	14.2	13.7	
g	1976-80	20-74	4.6	5.9	5.2	Diagnosed diabetes
		20-74	4.0	4.6	4.4	Undiagnosed diabetes; see Table 5 for detail
e	1979	All	2.26	3.84	3.10	See Table 2 for detail
e	1980	All	2.71	3.96	3.38	See Table 2 for detail
e	1981	All	2.64	3.66	3.19	See Table 2 for detail
State Surveys						
h	MI, 1980	All	6.5	10.1	8.8	Black/white = 1.7; higher than white rate for all age-sex groups except 65+ females
		18-34	3.0	3.2	3.1	
		35-44	3.2	6.4	5.5	
		45-64	11.1	22.3	17.8	
		65+	12.2	13.4	13.0	
i	CA, 1979	18+			5.3	Black/white = 1.3
j	1983	18+	4.7	6.8	5.8	Black/white = 1.9
		18-44			0.7	
		45-64			14.3	
		65+			22.7	
k	AL, 1982	18+	8.9	8.4	8.6	Black/white = 1.6

(Continued)

TABLE 1. (Continued)

Reference	Year	Age (Years)	Percent Diabetic*			Comments
			Male	Female	Both	
Community-Based Surveys						
l	Evans Co., GA, 1960-62	40-69	3.0	6.6	-	
m	Northern CA 1964-68	15+	9.4	5.3	-	Health maintenance organization population
n	Chicago, IL 1967-73	Adults	3.1	2.5	-	Industrial population

*Diabetes was ascertained by previous medical history in all studies except the 1976-80 U.S. study, where a 75-gram oral glucose tolerance test was used to detect undiagnosed diabetes, and the Northern California study, where diabetes was defined as 1-hour post-glucose >170 mg/dl.

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l. Deubner, DC, WE Wilkinson, MJ Helms, HA Tyroler, and CG Hames. Logistic model estimation of death attributable to risk factors for cardiovascular disease in Evans County, Georgia. Am J Epidemiol 112:135-43, 1980. (338 males and 396 females were included in this study.)

m. Dales, LG, AB Siegelaub, R Feldman, GD Friedman, CC Seltzer, and MF Collen. Racial differences in serum and urine glucose after glucose challenge. Diabetes 23:327-32, 1974. (5,337 males and 7,338 females were included in this study).

n. Cooper, R, K Liu, J Stamler, et al. Prevalence of diabetes and associated risk factors in blacks and whites: The Chicago Heart Association Detection Project in Industry. Unpublished data.

National Surveys

The National Health Surveys conducted by the National Center for Health Statistics have, since 1963, assessed the prevalence of diagnosed diabetes in blacks and whites. These surveys involve an interview in the home in which it is determined whether anyone in the household had been diagnosed by a physician as having diabetes. From 1963 to 1979-81 (the most recent available data), the prevalence of diabetes increased 175 percent in blacks and 106 percent in whites (Table 1). In 1979-81, the rate in black males was 16 percent greater than the rate in white males, and the rate in black females was 50 percent greater than the rate in white females (Table 2).

TABLE 2. *Number and rate of diagnosed diabetes in blacks and whites, United States, 1979-81*

	Black Diabetic Population (Thousands of Persons)			Rate of Diabetes Per 1,000 Black Persons			Rate of Diabetes Per 1,000 White Persons		
Age (Years)	Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female
All ages	834	305	529	32.2	25.4	38.2	23.8	21.9	25.6
0-24	20	6	14	1.5	.9	2.1	2.0	1.7	2.2
25-44	144	59	85	21.6	20.0	22.8	11.0	9.1	12.8
45-54	194	92	102	85.3	87.9	83.1	37.4	36.0	38.9
55-64	215	73	142	118.1	89.2	141.5	62.8	67.3	58.7
65-74	172	57	115	129.3	102.1	149.5	83.4	86.8	80.7
75+	90	19	71	130.9	72.6	168.1	86.0	79.5	89.8

SOURCE: Drury, TF, Division of Epidemiology and Health Promotion, from pooled data of the 1979, 1980, and 1981 National Health Interview Surveys, National Center for Health Statistics.

State and Community Surveys

There have been a number of recent state surveys of diabetes that have reported data on blacks. In those cited in Table 1, the black/white ratios were all greater than 1.0. There have also been several surveys of local United States populations that included black subjects (Table 1). In 1960-62 in Evans County, Georgia, the prevalence of diabetes in black adults was 3.0 percent for males and 6.6 percent for females. The black female rate was higher than the white female rate; the black male rate was lower than the white male rate. In contrast to other recent reports, there are two studies in which the prevalence of diabetes was lower in blacks than in whites; both involved primarily employed persons. In an industrial population in Chicago in 1973, the age-standardized prevalence of diabetes based on medical history of diabetes or the results of a screening test was lower in black women than in white women, and lower in black men than in white men. Similarly, in 1964-68 among members of the Northern California Kaiser Health Plan, the proportion with 1-hour post-glucose challenge levels greater than 170 mg/dl was significantly lower among both black males and females than among whites.

In the studies described above, when analysis by sex was presented, the black female diabetes rate was usually higher than the black male rate (Table 3). Also, when analysis by age was presented, the prevalence of diabetes in blacks increased with age (Tables 1 and 2).

TABLE 3. *Female-to-male ratios among United States blacks with diabetes*

Reference	Location	Year	Group	Female/Male Ratio
a	New York, NY	1931	Clinic patients	3.5
b	New York, NY	1942	Clinic patients	4
c	Oklahoma	1943	Clinic patients	5
d	Nashville, TN	1959-60	Clinic patients	3
e	Evans County, GA	1960	Population sample	2.2
f	Northern CA	1964-68	Health Maintenance Organization	0.6
g	Chicago	1973	Industrial population	0.8
h	United States	1979-81	Population sample	1.5
i	Michigan	1980	Population sample	1.6
j	Alabama	1982	Population sample	0.9
k	California	1983	Population sample	1.4

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Prevalence in African Blacks

The diabetes prevalence estimates of blacks in Africa have ranged from 0.0 to 3.0 percent with a mode of less than 1.0 percent. Almost all African studies have been hospital or clinic based, which has two major drawbacks: the studies are dependent on 1) the selection of cases for hospitalization, and 2) the rate at which patients with other diseases are hospitalized. Although some studies, particularly in urban areas, have reported prevalences similar to those in United States blacks (Goldberg et al. 1969, Mngola et al. 1976), most studies suggest that the prevalence of diabetes is less common in African blacks (Politzer et al. 1960, Campbell 1963, Politzer and Schneider 1962, Dodu 1964, Dodu 1958a, Davidson 1963, Goodall and Pilbeam 1964, Mills 1930, Kinnear 1963, Osuntokun et al. 1971, Wicks et al. 1973, Zieman 1907, Dubois 1944, Orr and Gilks 1931, Turner 1962, Mngola 1982, Cook 1901, Tulloch 1962, Tulloch 1965, Keeley 1957, Seftel and Abrams 1960). In Africa, a variable but sizable proportion of the population with diabetes have diabetes secondary to hemosiderosis and pancreatic calcification of unknown etiology (Stefel and Abrams 1960, Dodu 1958b), so the estimate of diabetes prevalence in parts of Africa is probably an overestimate of NIDDM prevalence. The few population-based surveys in Africa are consistent with the results of clinic studies. Population surveys in Rhodesia found diabetes to be rare among rural blacks (Carr and Gelfand 1961, Wicks and Jones 1973). In urban Africa the prevalence was as low as 0.3 percent in Rhodesia (Wicks and Jones 1973) and as high as 2.95 percent in Transvaal (Goldberg et al. 1969). The higher prevalence in urban areas relative to rural areas appeared greater in females (Jackson 1970). The lower prevalence in Africa has been attributed to younger age distribution, more rural inhabitants, and decreased access to medical care. All these studies are plagued with problems of limited or biased samples or having inadequate screening and diagnostic techniques for diabetes. For example, in the Capetown population, a twofold variation in prevalence was found, depending on method of diagnosis (Jackson 1970).

PREVALENCE OF IDDM IN YOUNG BLACKS

It has been a consistent observation that the prevalence of diabetes in young American blacks is less than in young American whites. However, most population-based surveys have been too insensitive to accurately estimate the prevalence of diabetes in young blacks; studies that suggest a lower prevalence among young blacks have most often been confined to clinic patients. A summary of studies is shown in Table 4. In the three United States surveys shown, prevalence was about 0.1 percent. Among outpatients in a clinic in Harlem, New York, in 1942, only 0.8 percent of 639 black diabetics were 10-19 years old, while 1.9 percent of 106 white diabetics were in this age group (Altschul and Nathan 1942); however, the low percent of diabetes in young black patients could have been due to a higher prevalence of diabetes among older blacks in the clinic population. In a small study at Charity Hospital in New Orleans, there was approximately equal racial distribution of 31 patients with diabetes under the age of 12, despite the fact that 80 to 85 percent of the general patient population of the hospital was nonwhite (Rosenbaum 1967). Among all children hospitalized in St. Louis Children's Hospital from 1960 to 1970, the rate of new admissions for diabetes among black children was less than 35 percent that of whites (MacDonald 1975). One possible explanation for this low rate was that black children with diabetes went to other local hospitals, but this did not seem to be correct. Another explanation, that the rate was lower because the rates of admission for other cause(s) were greater in blacks than in whites, was not addressed in either the New Orleans or St. Louis studies.

No United States population surveys have had sufficient numbers to accurately determine the prevalence of diabetes in children in the United States. The National Health Interview Surveys conducted in 1964-65 showed that 8.3 percent of diabetic whites were younger than 25 years at diagnosis (4.6 percent younger than age 15), while only 3.4 percent of diabetic nonwhites were younger than 25 years at diagnosis (0.3 percent younger than age 15) (Bauer 1967). This type of estimate cannot be used as a direct measure of comparative prevalence since it is dependent on the numbers of diabetics in the older age group. The National Health Interview Survey in 1973 revealed a prevalence of 1.3 per 1,000 for nonwhites less than 17 years of age, while the prevalence for whites was 1.4 per 1,000 (Table 4). The sample size of nonwhites in all these surveys is considered too small to reliably estimate prevalence of diabetes.

TABLE 4. *Prevalence of diabetes in young United States blacks*

Reference	Location	Year	Age (Years)	Prevalence* (Percent)	Comments
a	United States	1965	<15	-	Those less than age 15 made up a greater % of white diabetics than black diabetics
b	United States	1973	<17	0.13	Very small sample; little difference between blacks and whites
c	United States	1979-81	<25	0.15	Small sample; little difference between blacks and whites
d	Atlanta, GA	1928	<20	(Rare)	
e	Harlem, NY	1942	10-19	-	Black diabetics in this age group were 0.8% of all diabetics; whites, 1.9%
f	New Orleans, LA	1967	<16	-	Preponderance of white diabetic juvenile diabetes patients relative to blacks
g	Erie Co., NY	1968	<16	0.03	Nonwhite prevalence was about half of white prevalence
h	Michigan	1973	School children	0.05	Review of school records; nonwhite prevalence was about half of white prevalence
i	St. Louis, MO	1975	<15	-	White diabetics made up greater % of hospital admissions of children
j	Pittsburgh, PA	1976	5-17	Nonwhite males, 0.14; nonwhite females, 0.15	White rate was 20% higher than nonwhite rate

*Diagnostic criteria: Previous medical history of diabetes or not stated.

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Based on a review of hospital and private medical office records from 1946-72 in Erie County, New York, the prevalence of diabetes in blacks age 16 years or younger was 29.5/100,000, about half that of white children (Sultz et al. 1978) (Table 4). A similar prevalence ratio was found in a mail survey of all Michigan school districts conducted in 1973 (Gorwitz et al. 1976). The existing studies have not provided estimates of the sex and age prevalences among United States black children with diabetes.

Very few attempts have been made to determine the prevalence of youth-onset diabetes in Africa by population surveys, but the prevalence of diabetes in non-United States black children has been variously interpreted to indicate that diabetes in this age group is rare (West 1979, MacDonald 1975), occasional (Jackson 1970), or not different from that found in white populations (Asmal et al. 1981). There are a number of problems with interpreting these estimates. Most studies in Africa have been confined to hospitalized or clinic patients, and sample sizes are small. Also, it is possible that children in rural Africa do not have access to health care and that the presence of diabetes has not been ascertained. Many cases which occur in the younger age group in Africa also seem to differ from the classical IDDM syndrome. Nonalcoholic calcific pancreatic diabetes in those under the age of 20 is common in Nigeria (Kinnear 1963, Osuntokun et al. 1971) and Uganda (Shaper 1961) but rare in Rhodesia (Gelfand and Forbes 1963) and South Africa (Seftel et al. 1963). Inclusion of such nonIDDM cases would lead to an overestimate of IDDM prevalence.

INCIDENCE OF IDDM IN YOUNG BLACKS

The incidence of diabetes in American black children has been studied in Pennsylvania and Alabama. The Pittsburgh IDDM registry, based on hospital record review and surveillance of pediatricians, indicates that the incidence (occurrence of new cases) of diabetes in white children during the period 1965-76 was 1.5 times that in nonwhite children (Table 5). When the incidence rates were compared within socioeconomic groups, the differential persisted, suggesting that the difference in incidence did not arise from socioeconomic differences (LaPorte 1981b). The mean age of onset was slightly greater for nonwhites than for whites (Table 5), but the population size was

TABLE 5. *Incidence of diabetes and mean age at onset in nonwhites and whites less than 20 years of age, Allegheny County, Pennsylvania, 1965-76*

Age (Years)	Nonwhites		Whites	
	Male	Female	Male	Female
	New Cases Per 100,000 Persons Per Year			
0-19*	10.10	11.06	16.02	14.79
<5	3.26	5.43	6.83	6.22
5-9	10.05	5.11	19.56	17.37
10-14	13.53	20.94	20.81	24.13
15-19	11.81	10.45	14.68	8.92
	Mean Age at Onset (Years)			
0-19	11.64	11.24	10.93	10.60

*Age-adjusted rate.

SOURCE: LaPorte, RE, HA Fishbein, AL Drash, LH Kuller, BB Schneider, TJ Orchard, and DK Wagener. The Pittsburgh insulin-dependent diabetes mellitus (IDDM) registry: The incidence of insulin-dependent diabetes mellitus in Allegheny County, Pennsylvania (1965-1976). Diabetes 30:279-84, 1981.

too small for valid conclusions. There was no significant difference in the incidence rates or the age of onset between nonwhite males and females (LaPorte et al. 1981a), and the distribution of incidence by season appeared similar between nonwhites and whites (Fishbein et al. 1982). Although the Pittsburgh registry is described as an IDDM registry, it is not clear that all cases were IDDM since the only criteria for inclusion were presence of insulin therapy at hospital discharge and age at onset less than 17 years. The results of the Alabama juvenile-onset diabetes registry revealed a similar incidence ratio of white to black children with diabetes (Wells et al. 1980).

HLA IN BLACK IDDMs

Studies of genetic markers at the major histocompatibility complex on chromosome 6 show that the allelic associations found in United States blacks with IDDM are similar to those found in United States whites. This is interpreted as support for the genetic admixture hypothesis. Increases in HLA-B8, B15, DR3, DR4, and BfF1 and decreases in B7 and DR2 have been reported in studies of United States blacks with IDDM (Rodey et al. 1979, Duquesnoy et al. 1979, Budowle et al. 1982, Reitnauer et al. 1981, Patel et al. 1977, Zeidler et al. 1980). In addition, it has been reported that United States blacks with IDDM have a pattern of genetic marker frequencies significantly more like that of the white population than do blacks without IDDM (Reitnauer et al. 1982). The classification of diabetes proposed by the NDDG (1979) includes a provisional research subclassification of IDDM in which there is an association of IDDM with organ-specific autoimmune disease or phenomena and persistent islet cell antibodies. Recent work suggests that the proportion of this subclass among blacks is less than among whites (Riley et al. 1980, 1981, 1982; Neufeld et al. 1980).

PREVALENCE OF UNDIAGNOSED NIDDM IN BLACKS

In all of the early national health surveys, only known diagnosed diabetics were ascertained, by interviewees reporting that they or a household member had been told by a doctor that they had diabetes. However, in the 1976-80 National Health and Nutrition Examination Survey, the presence of undiagnosed diabetes that met NDDG criteria was determined from oral glucose tolerance tests in persons with no medical history of diabetes. Table 6 shows the prevalence of diabetes in black males and females together with the rates in their white counterparts. Rates increase with age and are higher in blacks than in whites in all age groups. For both races, the rates of undiagnosed diabetes in the 20-74 year age group are about equal to the rates of diagnosed diabetes shown in Table 1. Similarly to diagnosed diabetes, black females have the highest rates of undiagnosed diabetes. In a study of "nondiabetic" volunteers for a diabetes screening program in Cleveland in 1964-67, the prevalence of previously undetected diabetes in nonwhites was 2.4 percent, which was the same as in whites (Kent and Leonards 1968).

PREVALENCE OF IMPAIRED GLUCOSE TOLERANCE

The NDDG in 1979 defined the category impaired glucose tolerance (IGT) to replace the older terms borderline or chemical diabetes. Persons are classified as IGT if their fasting plasma glucose levels are less than 140 mg/dl and their levels after a 75-gram oral glucose challenge are greater than or equal to 200 mg/dl at 1 hour and 140-199 mg/dl at 2 hours. Table 6 shows the prevalence of IGT in blacks and whites. Unlike diagnosed and undiagnosed diabetes, the IGT rate for blacks did not increase with age. IGT rates in black females are the lowest of the four race/sex groups.

TABLE 6. *Percent (and standard error) of adults ages 20-74 years with undiagnosed diabetes and impaired glucose tolerance, United States, 1976-80*

	Age (Years)				
	20-74	20-44	45-54	55-64	65-74
			Undiagnosed Diabetes*		
All races					
Both sexes	3.2 (.35)	.9 (.31)	4.2 (.81)	6.2 (1.03)	8.4 (.84)
Male	2.8 (.41)	.8 (.39)	3.6 (1.28)	4.0 (1.03)	9.5 (1.42)
Female	3.6 (.42)	1.0 (.38)	4.7 (1.14)	8.1 (1.68)	7.6 (.89)
White					
Both sexes	3.0 (.38)	.7 (.31)	4.0 (.90)	5.9 (1.24)	8.0 (.85)
Male	2.5 (.36)	.5 (.27)	3.2 (1.25)	3.8 (1.00)	9.0 (1.38)
Female	3.4 (.52)	.8 (.40)	4.6 (1.25)	7.9 (2.08)	7.3 (.95)
Black					
Both sexes	4.4 (.91)	.9 (.68)	7.2 (3.05)	7.7 (3.75)	12.3 (3.94)
Male	4.0 (1.72)	1.0 (.98)	7.5 (6.40)	5.2 (3.94)	12.2 (7.23)
Female	4.6 (1.35)	.9 (.91)	7.0 (3.70)	9.1 (5.92)	12.3 (4.50)
			Impaired Glucose Tolerance*		
All races					
Both sexes	4.6 (0.4)	2.1 (0.4)	7.0 (1.0)	7.4 (0.9)	9.2 (0.8)
Male	4.6 (0.6)	1.2 (0.4)	7.3 (1.7)	9.8 (1.5)	8.9 (1.5)
Female	4.7 (0.7)	2.8 (0.7)	6.7 (1.5)	5.2 (1.3)	9.4 (1.2)
White					
Both sexes	4.6 (0.4)	2.0 (0.4)	6.3 (1.1)	7.7 (1.0)	9.5 (0.9)
Male	4.4 (0.6)	1.0 (0.3)	6.4 (1.8)	10.1 (1.5)	9.0 (1.5)
Female	4.7 (0.7)	2.8 (0.7)	6.2 (1.1)	5.5 (1.5)	9.9 (1.2)
Black					
Both sexes	3.8 (0.8)	1.2 (0.8)	10.7 (3.3)	4.5 (2.3)	3.4 (2.3)
Male	5.9 (1.2)	1.4 (1.3)	18.8 (4.0)	7.0 (4.9)	5.4 (4.1)
Female	2.3 (1.3)	1.1 (1.1)	5.1 (4.9)	3.1 (2.2)	1.9 (2.3)

*Based on results of 75-gram oral glucose tolerance tests (OGTTs) administered in the morning after an overnight 10- to 16-hour fast, in persons who reported that they had no medical history of diabetes. OGTTs were classified using National Diabetes Data Group criteria. Adjusted to the 1978 United States population.

SOURCE: Hadden, WC, and MI Harris. Prevalence of diagnosed diabetes, undiagnosed diabetes and IGT in adults 20-74 years of age. National Center for Health Statistics Series 11, in preparation.

PLASMA GLUCOSE VALUES IN THE BLACK POPULATION

Table 7 shows the mean and percentile distribution of plasma glucose values of black persons with no medical history of diabetes in the fasting state and 2 hours after a 75-gram oral glucose challenge. The mean values are not statistically different from values of whites, nor are differences in means between black males and black females statistically significant.

TABLE 7. *Venous plasma glucose concentrations of blacks ages 20-74 years with no medical history of diabetes, United States, 1976-80*

Sex and Age (Years)	Mean	Standard Deviation	Standard Error	Percentiles				
				10th	25th	50th	75th	90th
				Fasting Plasma Glucose				
Both Sexes								
20-44	89.8	16.3	1.28	78	83	88	95	103
45-64	97.5	19.8	1.35	82	89	94	102	111
65-74	97.2	16.2	1.80	86	88	94	103	112
Male								
20-44	94.1	12.2	1.34	80	88	92	98	106
45-64	95.7	12.8	1.60	82	89	96	104	108
65-74	98.5	18.9	3.01		90	96	101	
Female								
20-44	86.7	18.6	1.87	76	80	84	89	97
45-64	98.7	24.1	2.31	82	89	92	102	128
65-74	96.5	16.5	3.17		88	91	105	
				Two-Hour Post 75-Gram Glucose Challenge				
Both Sexes								
20-44	102.6	40.0	2.41	71	82	94	116	148
45-64	126.1	53.9	4.89	81	95	115	147	179
65-74	137.4	59.3	7.83	96	106	123	149	239
Male								
20-44	95.5	26.9	2.25	69	83	93	108	126
45-64	124.8	44.3	6.31	79	101	116	149	167
65-74	140.1	60.8	13.36		106	127	156	
Female								
20-44	107.7	47.7	3.60	74	82	99	128	155
45-64	126.9	61.4	6.70	81	95	113	147	202
65-74	135.5	63.8	9.86		106	114	140	

SOURCE: Hadden, WC, and MI Harris. Prevalence of diagnosed diabetes, undiagnosed diabetes and IGT in adults 20-74 years of age. National Center for Health Statistics Series 11, in preparation.

COMPLICATIONS

There have been very few studies in the United States examining the prevalence and natural history of diabetic complications in blacks and even fewer comparing directly blacks and whites, controlling for duration of diabetes. The differences in mortality rates between United States blacks and whites (see below) suggest that the disease may be more severe in blacks, but they do not take into account differences in incidence, age of onset, medical care, education, socioeconomic status, and the presence of hypertension.

Macrovascular Disease

There is evidence that blacks with diabetes relative to blacks without diabetes are at increased risk for macrovascular disease. The prevalence of these complications in blacks increases with duration of diabetes, as it does for whites. The great variability in rates of macrovascular disease in studies of black diabetics in the United States and in Africa suggests that diabetes and race alone are not sufficient factors in the etiology of macrovascular disease. As for whites, there is some controversy as to whether the rate of atherosclerosis in black diabetic populations is directly related to diabetes. The relative prevalence of macrovascular disease in United States blacks and whites has been the subject of disagreement (Moriyama et al. 1971, Mihaly and Whiteman 1958, Anderson et al. 1961, Weisse et al. 1977). However, myocardial infarction appears to be less frequent among blacks than among whites (Burch and Voorhies 1939, McVay and Keil 1955, Keil and McVay 1956, Thomas et al. 1957, Phillips and Burch 1959, Hagstrom et al. 1971, Kuller et al. 1973, Cassel et al. 1971). While 54 percent of deaths in whites in which diabetes was a contributing cause of death were due to ischemic heart disease in 1978, only 43 percent were due to ischemic heart disease in blacks (see Table 11). As for whites, the rate of myocardial infarction in black diabetics appears to be increased relative to nondiabetics (Cooper et al. unpublished, Robertson and Strong 1968). Among employed Chicago volunteers, after adjusting for blood pressure, cholesterol, and cigarette smoking, the rate of cardiovascular disease was lower for blacks with diabetes than blacks without diabetes (Cooper et al. unpublished).

Until recently, macrovascular disease was considered to be very rare in African blacks (Seftel and Schultz 1961, Bourgoignie 1962, Kinnear 1963, Gelfand and Forbes 1963, Campbell 1963, Haddock 1964), and in African diabetics the rates of macrovascular disease have also been low (Seftel 1964, Greenwood and Taylor 1968, Jackson et al. 1966, Osuntokun et al. 1971, Wicks and Jones 1973). However, despite the low rates, as in the United States, the rate of macrovascular disease for diabetics in Africa seems to be increased relative to nondiabetics (Dodu 1958a, Seftel 1973, Chukwuemeka et al. 1972, Greenwood and Taylor 1968) and in more urbanized areas, both the rate of diabetes and the rate of macrovascular disease appear to be higher than in rural areas (Jackson 1970).

Hypertension

In the United States, blacks have a higher prevalence of hypertension than whites. In 1976-80, 22.8 percent of blacks ages 25-74 years had systolic of 160 mm and diastolic of 95 mm or greater, while only 13.5 percent of whites did (NCHS 1982). Hypertension and diabetes have been found together in individuals more frequently than would be expected (Tulloch 1962). In a hypertension survey in Michigan, the rate of hypertension in blacks with diabetes was 53.8 percent versus 29.2 percent among nondiabetic blacks. The hypertension rate among black diabetics was only slightly greater than the white diabetic hypertension rate of 51.3 percent (Halpern et al. 1983).

Retinopathy

Blindness registry data indicate that retinopathy may be more prevalent in blacks with diabetes than in diabetic whites (Kahn and Hiller 1974). The age-standardized prevalence of blindness secondary to diabetic retinopathy was more than twice as great for nonwhites than for whites (13.6/100,000 vs. 5.9/100,000). The rates were consistently higher in both black males and black females, and females had almost three times the rate of males.

The reported rates of retinopathy in African blacks have ranged from 4.1 percent to 54.0 percent (Shaper 1958, Steele et al. 1977, Beheyt and Joris 1960, Bourgoignie 1962, Gordon and Mokete 1981, Gelfand and Forbes 1963, Otim 1975, Campbell 1963, Jackson 1966, Seftel and Walker 1966, Morley et al. 1977, Haddock 1964, Kinnear 1963, Osuntokun et al. 1971). Where duration of diabetes was reported, the prevalence of retinopathy increased with duration, and in Bantus from South Africa, when duration of diabetes was considered, there was very little difference in prevalence from other ethnic groups (Jackson et al. 1966).

Kidney Disease

The incidence of end-stage renal disease (ESRD) due to diabetic nephropathy appears to be almost three times greater among blacks than among whites (Eggers 1984). The rate of diabetic ESRD among blacks was 40 per million population in the United States in 1980, but only 14 per million among whites. The rate was 3.3 times higher in blacks than in whites in southeastern Michigan in 1973-75 (Easterling 1977) and 3.4 times higher in Jefferson County, Alabama, in 1974-78 (Rostand et al. 1982). Higher rates of hypertension may contribute to the excess prevalence of clinically diagnosed diabetic nephropathy among blacks.

Pregnancy

The diabetic natality rate (deliveries of diabetic women per 1,000 total deliveries) was slightly higher for black diabetic women compared to white diabetic women in South Carolina in 1978. Through retrospective review of birth and fetal death certificates and maternal hospital discharge records in 1978, 6.9 deliveries of black diabetic women occurred per 1,000 deliveries of black women, compared to 5.1 per 1,000 for white diabetic women (Table 8). However, the perinatal mortality rate among black diabetics was three times that of white diabetics and was 8.5 times that of white nondiabetics.

TABLE 8. *Pregnancy outcome among white and nonwhite diabetics* and nondiabetics, South Carolina, 1978*

	White Diabetic	Nonwhite Diabetic	White Nondiabetic	Nonwhite Nondiabetic
Number of deliveries	150	144	29,182	20,746
Diabetic natality rate	5.1/1,000	6.9/1,000	-	-
Number of perinatal deaths	8	22	525	705
Perinatal deaths/1,000 deliveries	53	153	18	34

*International Classification of Diseases numbers 250 and 648.0.

SOURCE: Wheeler, FC, CW Gollmar, and LC Deeb. Diabetes and pregnancy in South Carolina. Diabetes Care 5:561-5, 1982.

Other Diabetic Complications

There is a paucity of published information on the incidence and prevalence in United States blacks of diabetic complications such as cerebrovascular disease, peripheral vascular disease, and neuropathy, but blacks may have increased severity of some of these complications. Cerebrovascular disease appears to be more prevalent among blacks with diabetes than among the nondiabetic population (Shafer et al. 1974). In South Carolina in 1978, about 95 per 10,000 black diabetics ages 45-64 years experienced a lower extremity amputation; for ages 65+ years, the rate was about 150 per 10,000. The amputation rate in black diabetics was significantly greater (2.3 times) than in white diabetics (Most and Sinnock 1983). In the United States in 1970-78, the age-adjusted death rate from diabetes with acidosis or coma was significantly higher for nonwhites than for whites (3.4 vs. 1.1 per 100,000). This was true in all regions of the United States. Among nonwhites the rates were highest in the South (3.9/100,000) and lowest in the West (2.0/100,000). The secular trend in acidosis or coma deaths since 1970 has showed a consistently downward trend that is greater for nonwhites than for whites (Holman et al. 1983).

African blacks with diabetes seem to have an increased likelihood of nonembolic cerebral infarction (Osuntokun et al. 1971). The prevalence of peripheral vascular disease in Zulus with diabetes was 0.5 percent, far less than the prevalence of 9.2 percent in Natal Indians (Campbell 1963). Most, but not all, reports of renal disease among African blacks with diabetes have found it to be uncommon, but there have been no recent reports (Haddock 1964, Greenwood and Taylor 1968, Gelfand and Forbes 1963, Osuntokun 1969, Parson et al. 1968, Seftel and Schultz 1961). The prevalence estimates of neuropathy in African blacks have varied more widely than any other complication (Kinnear 1963, Osuntokun 1969, Haddock 1964, Gelfand and Forbes 1963, Goodall 1964, Greenwood and Taylor 1968, Markman et al. 1959, Gordon and Mokete 1981, Morley et al. 1977, Asmal et al. 1981). In part this may reflect the difficulty in defining neuropathy and that those with neuropathy may be less likely to seek medical attention than those with other diabetic complications, particularly in areas of Africa where medical care is limited.

MORTALITY

Before World War II, diabetes was less commonly identified as a cause of death among blacks in the United States than among whites (Table 9). Data from most states going back to 1910 and from the Metropolitan Life Insurance Company are consistent with this, although there were areas in the South, especially urban areas, where the ratio was reversed (Emerson and Larimore 1924). Since World War II, relative mortality rates have reversed, with blacks having a higher recorded death rate from diabetes than whites. In both races there is evidence of a decline in the underlying cause death rate from diabetes. In white females, the decline began as early as 1955, while in white males and in blacks, both male and female, the decline did not begin until after 1970 (Table 9). Black females have a much higher recorded mortality from diabetes than black males do, although the female-to-male ratio in death rate for blacks has declined from 2.0 in 1950 to 1.2 in 1980. The female-to-male ratio in mortality has consistently been greater for blacks than for whites, although it has decreased for both races (Table 9).

In blacks, as in whites, the death rate attributed to diabetes increases with age (Table 10). Until recently the death rate peaked at younger ages for nonwhites. This could be interpreted to reflect the overall shorter duration of life of nonwhites as well as possible earlier age of diabetes onset. In the most recent data of 1980, however, death rates from diabetes increase with age in all race/sex groups (Table 10). Because the death rate for diabetes may depend on access to medical care, adequacy of medical care, competing causes of death, the individual decision of the physician concerning what to assign as cause of death, and the prevalence of diabetes, mortality rates have questionable validity in estimating the scope and impact of diabetes in the black population.

TABLE 9. *Age-adjusted* death rates from diabetes as the underlying cause of death per 100,000 population, and female/male ratios, by race and sex, United States, 1938-1980*

	White			Black		
Year	Males	Females	Female/Male Ratio	Males	Females	Female/Male Ratio
1938	18.9	31.1	1.6	13.2	29.0	2.2
1940	20.6	32.8	1.6	15.0	32.2	2.1
1945	18.3	29.1	1.6	13.7	27.9	2.0
Rates before 1949 are not comparable to those after 1949 because of changes in the classification of causes of death in that year.						
1950	11.3	16.4	1.5	11.5	22.7	2.0
1955	11.0	14.3	1.3	11.7	22.7	1.9
1960	11.6	13.7	1.2	16.2	27.3	1.7
1965	11.9	12.8	1.1	17.7	28.0	1.6
1970	12.7	12.8	1.0	21.2	30.9	1.5
1975	10.7	10.2	1.0	18.7	26.0	1.4
1980	9.5	8.7	0.9	17.7	22.1	1.2

*Age-adjusted to the total population of the United States in 1940.

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

TABLE 10. *Number of deaths and death rate from diabetes as the underlying cause of death by age, sex, and race, United States, 1980*

Age at Death (Years)	Number of Deaths	Death Rate*	Number of Deaths	Death Rate*
	White Males		Black Males	
All ages	12,125	13.23	2,010	16.05
Under 25	65	0.17	26	0.39
25-34	260	1.70	55	2.81
35-44	373	3.49	120	9.75
45-54	853	8.93	216	21.18
55-64	2,217	24.58	489	57.45
65-74	3,682	61.06	577	102.1
75-84	3,314	128.9	415	182.8
85+	1,361	221.7	112	211.3
	White Females		Black Females	
All ages	16,734	17.31	3,534	25.30
Under 25	68	0.19	20	0.29
25-34	192	1.25	58	2.58
35-44	283	2.60	107	7.23
45-54	741	7.37	328	26.24
55-64	2,231	21.87	739	70.0
65-74	4,583	58.23	1,143	147.7
75-84	5,507	124.6	806	224.5
85+	3,138	219.4	333	314.2

*Death rate: number of underlying cause deaths in each age/race/sex group divided by the number of 100,000 living persons in the group.

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

Among death certificates filed in the United States in 1978 in which diabetes was the underlying cause of death in blacks, ischemic heart disease was the most frequent contributing cause of death and was present on 42.7 percent of certificates (Table 11). Other heart diseases, cerebrovascular diseases, and renal diseases were each present on about one-fourth of the certificates, with other conditions represented in lower proportions.

DIABETES AS A CONTRIBUTING CAUSE OF DEATH IN BLACKS

Underlying cause of death data (which form the basis for Tables 9–11) seriously underestimate the contribution of diabetes to mortality, because many persons with diabetes die as a result of complications or other diseases that are themselves ascribed as the cause of death. Diabetes is selected as the underlying cause in deaths of blacks in only one-third of death certificates on which it appears. In 1978, only 5,377 deaths of blacks were attributed to diabetes; however, it appeared on an additional 10,491 death certificates. Table 12 illustrates the underlying causes of death in these diabetics. Cardiovascular conditions were by far the most frequent, occurring in 71 percent, with ischemic heart disease being the most common cardiovascular condition and cerebrovascular disease being the next most common condition.

TABLE 11. *Percent of diabetes underlying cause death certificates of blacks listing certain contributing causes, United States, 1978*

Contributing Cause of Death	ICD Number	Number	Percent of Total
Infectious and parasitic diseases	000-136	487	9.1
Neoplasms (benign and malignant)	140-239	153	2.8
Endocrine, nutritional, metabolic diseases	240-279	279	5.2
Blood diseases	280-289	111	2.1
Mental system diseases	290-315	192	3.6
Nervous system diseases	320-389	251	4.7
Hypertensive diseases	400-404	347	6.5
Ischemic heart disease	410-414	2,297	42.7
Other forms of heart disease	420-429	1,396	26.0
Cerebrovascular diseases	430-438	1,257	23.4
Diseases of arteries, arterioles, capillaries	440-458	852	15.8
Respiratory system diseases	460-519	504	9.4
Digestive system diseases	520-577	331	6.2
Genitourinary system diseases	580-629	1,126	20.9
Nephritis/nephrosis	580-584	463	8.6
Other renal diseases	593.2	442	8.2
Accidents, poisoning, violence	E800-999	137	2.5
Total	-	5,377	100.0

SOURCE: Harris, M, National Diabetes Data Group, from unpublished data on death certificates in the United States in 1978, National Center for Health Statistics.

TABLE 12. *Percent distribution of diabetes listed as a contributing cause of death on death certificates of blacks, United States, 1978*

		Age at Death (Years)			
Underlying Cause of Death	ICD Number	All	0-34	35-64	65+
Infectious and parasitic diseases	000-136	1.9	6.8	2.5	1.5
Neoplasms (benign and malignant)	140-239	11.2	2.9	11.8	11.0
Endocrine, nutritional, metabolic diseases	240-279	0.8	1.9	0.9	0.6
Blood diseases	280-289	0.3	1.0	0.3	0.2
Mental system diseases	290-315	0.6	2.9	1.0	0.3
Nervous system diseases	320-389	0.7	6.8	1.0	0.4
Cardiovascular diseases	390-458	71.0	29.1	66.9	74.0
Hypertensive diseases	400-404	2.8	5.8	2.6	2.9
Ischemic heart disease	410-414	45.4	7.8	44.3	46.6
Other forms of heart disease	420-429	3.2	4.9	3.9	2.8
Cerebrovascular diseases	430-438	15.5	2.9	12.1	17.7
Diseases of arteries, arterioles, capillaries	440-458	3.6	4.9	3.4	3.8
Respiratory system diseases	460-519	4.9	20.4	4.7	4.7
Digestive system diseases	520-577	3.4	7.8	5.1	2.4
Genitourinary system diseases	580-629	3.5	7.8	3.5	3.4
Nephritis/nephrosis	580-584	1.4	1.9	2.0	1.1
Other renal diseases	593.2	0.7	2.9	0.6	0.8
Accidents, poisoning, violence	E800-999	1.3	5.8	1.6	1.0
All others - complications of pregnancy, skin diseases, musculoskeletal diseases, congenital anomalies, perinatal mortality, symptoms and ill-defined conditions	630-796	0.6	6.8	0.6	0.4
Total	-	100.0	100.0	100.0	100.0
Number of certificates	-	10,491	103	3,843	6,545

SOURCE: Harris, MI, National Diabetes Data Group, from unpublished data on death certificates in the United States in 1978, National Center for Health Statistics.

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APPENDIX A. *Prevalence of black Americans, by age and sex, 1980*

Age (Years)	Black Males (Thousands)	Black Females (Thousands)
All Ages	12,516	13,972
Under 25	6,615	6,691
25-34	1,955	2,254
35-44	1,228	1,480
45-54	1,019	1,251
55-64	851	1,056
65-74	565	774
75-84	227	359
85+	53	106

SOURCE: United States Bureau of the Census.

APPENDIX B. *Increase in the nonwhite* United States population*

	Age (Years)					
	0-54		55+		All Ages	
Year	Number (Millions)	Percent of Population	Number (Millions)	Percent of Population	Number (Millions)	Percent of Total Population
1930	11.8	10.9	1.00	6.6	12.8	10.4
1950	14.3	11.4	1.88	7.4	16.2	10.7
1970	22.1	13.4	3.51	9.1	25.6	12.5
1980	33.1	18.4	5.1	10.8	38.1	16.8
1980 (black only)	22.5	12.5	4.0	8.4	26.5	11.7

*Includes blacks, American Indians, Eskimos, Aleuts, Asian and Pacific Islanders, and others; blacks constituted 69% of this group in 1980.

SOURCE: Harris, MI, National Diabetes Data Group, from reports of the United States Bureau of the Census.

APPENDIX C. *Rates of diagnosed diabetes by race and sex groups, United States, 1976*

Race and Sex	Crude Rate Per 1,000	Age-Standardized* Rate Per 1,000	Age-Std. Rate/ All Age-Std. Rate
All	21.60	21.60	1.0
All males	19.52	20.80	0.96
All females	23.55	22.34	1.03
All whites	21.04	20.39	0.94
All blacks	26.19	32.67	1.51
White males	19.29	19.96	0.92
White females	22.69	20.77	0.96
Black males	21.09	27.85	1.29
Black females	30.66	36.58	1.69

*Age-standardized to the United States population of 1976.

SOURCE: Harris, MI, National Diabetes Data Group, from unpublished data of the 1976 Health Interview Survey, National Center for Health Statistics.

APPENDIX D. *Time trends in the number and rate of diagnosed diabetes, by race, United States*

Year	Number of Diabetics (Thousands)				Rate per 1,000 Population			
			Other				Other	
	All Races	White	All Other	Black	All Races	White	All Other	Black
1963	2,101	1,856	245	228	11.5	11.5	11.4	11.7
1964	2,313	2,030	283	256	12.4	12.4	13.0	12.7
1965	2,385	2,076	309	277	12.7	12.5	13.9	13.8
1966	2,772	2,453	319	304	14.5	14.6	14.0	14.6
1967	3,091	2,703	388	355	16.1	16.0	16.8	16.9
1968	3,175	2,781	395	372	16.2	16.2	16.6	17.0
1973	4,191	3,570	622	585	20.4	19.9	23.9	24.7
1975	4,780	4,040	740	704	22.9	22.2	27.2	28.9
1976	4,974	4,212	762	700	23.6	23.0	27.4	28.2
1978	5,193	-	-	-	23.7	23.3	-	29.1
1979-81	5,429	4,512	917	834	24.7	23.8	30.5	32.2

SOURCE: National Diabetes Data Group, compiled from data of the National Health Interview Surveys, National Center for Health Statistics.

APPENDIX E. *Number and percent distribution of office visits of black patients and all patients, United States, 1975-76*

Major Diagnostic Groups	ICDA 8 Code	Number of Visits By Black Patients (Thousands)	Percent of Visits By	
			Black Patients	All Patients*
Infective and parasitic diseases	000-136	4,410	4.9	4.2
Neoplasms	140-239	1,468	1.6	2.2
Endocrine, nutritional, metabolic diseases	240-279	4,270	4.7	4.2
Diabetes	250	2,228	2.5	1.7
Obesity	277	1,329	1.5	1.4
Mental disorders	290-315	3,068	3.4	4.2
Diseases of nervous system	320-389	4,998	5.5	8.2
Diseases of circulatory system	390-458	9,366	10.4	9.6
Hypertension	401	5,019	5.6	4.0
Chronic ischemic heart disease	412	1,743	1.9	2.3
Diseases of respiratory system	460-519	14,704	16.3	14.1
Diseases of digestive system	520-577	2,999	3.3	3.3
Diseases of genitourinary system	580-629	6,822	7.5	6.2
Diseases of skin and subcutaneous tissue	680-709	4,445	4.9	5.3
Diseases of musculoskeletal system	710-738	5,271	5.8	5.7
Symptoms and ill-defined conditions	780-796	4,063	4.5	4.7
Accidents, poisonings, and violence	800-999	8,140	9.0	7.3
Conditions/exams without sickness	Y00-Y13	14,295	15.8	18.1
Other diagnoses		1,365	1.5	1.4
Diagnosis "none" or "unknown"		788	0.9	1.3
All visits		90,484	100.0	100.0

*Based on 1,155,900,228 office visits by patients of all races over the 2-year span 1975-76.

SOURCE: Koch, H, and RO Gagnon. Office visits by black patients. National Ambulatory Care Survey, United States 1975-76. National Center for Health Statistics. Advance Data, No. 50, July 23, 1979.

CHAPTER IX. DIABETES IN HISPANIC AMERICANS

Michael P. Stern, M.D.

SUMMARY

There are about 15 million persons of Spanish origin in the United States. About 10-12 percent of Mexican American adults have diabetes, greater than 95 percent of which is the noninsulin-dependent type (NIDDM). A distinct socioeconomic gradient is present, with NIDDM being two to four times as common in low income (barrio) Mexican Americans as in upper income (suburban) Mexican Americans. Diabetes is about 2.8 times as frequent in Mexican American men as in all white men in the United States and about 1.5 times as frequent in Mexican American women as in all white women. Explanations for these differences in prevalence include higher rates of obesity in Mexican Americans, particularly women, lower family income, and higher percent of native American genetic admixture in Mexican Americans than in all whites in the United States.

In Puerto Rico, NIDDM prevalence is higher in urban than in rural residents, although the overall prevalence does not appear to be as high as in Mexican Americans. These differences do not appear to be due to differences in obesity, at least in urban dwellers. There do not appear to be any studies of diabetes prevalence in Puerto Ricans living in the United States or studies of Cuban Americans.

METHODOLOGY OF STUDIES OF DIABETES IN HISPANIC AMERICANS

The variable criteria used to define diabetes in studies on Hispanic Americans are problematic. Relatively few studies have used the new National Diabetes Data Group (NDDG) criteria. Even when NDDG criteria have been used, however, methodological differences between studies may have unexpectedly large effects on reported prevalence rates. Not all studies have distinguished between noninsulin-dependent diabetes (NIDDM) and insulin-dependent diabetes (IDDM). In this chapter, the term "diabetes" will be used when the two types have not been distinguished, and the terms "IDDM" and "NIDDM" will be used when these types are specifically referred to.

A further problem is how to classify patients who give a history of diabetes but who do not meet the NDDG criteria at the time they are studied. In this chapter, such pa-

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tients are considered to be diabetic only if they reported taking insulin or oral antidiabetic agents. This approach, however, could only be used when information on the use of antidiabetic medication was available. The rationale for this decision was that, since the new NDDG criteria are set higher than former criteria, it is possible that a number of persons who were diagnosed using former criteria would not now be considered to have diabetes. The policy that has been adopted requires that all patients meet NDDG criteria unless they were known to be taking hypoglycemic agents at the time of study.

There are only three published studies of diabetes prevalence in Mexican Americans, all conducted in southern Texas. Data on diabetes prevalence in Puerto Rico are also available, although there do not appear to be any studies of diabetes prevalence among Puerto Ricans living outside Puerto Rico or among Cuban Americans. Although diabetes is unquestionably a major cause of morbidity and mortality among Hispanic Americans, there is still a major need for additional studies to better define the magnitude and scope of this important health problem. The Hispanic Health and Nutrition Examination Survey (HHANES) now being conducted should provide new data on Mexican Americans, Puerto Ricans, and Cubans from multiple sites across the United States.

IDDM VERSUS NIDDM IN HISPANIC AMERICANS

The great majority of diabetics identified in population-based studies of adult Hispanic Americans are of the NIDDM type. In the San Antonio Heart Study, for example, while 15 of 142 Mexican American diabetics 25-64 years old were insulin takers, 9 of these 15 were considered on the basis of obesity (BMI greater than 30.0 kg/m^2) and/or age of onset (greater than 40 years) to have NIDDM despite their having been treated with insulin (Stern et al. 1984). Thus only 4 percent of Mexican American diabetics might possibly have been classified as having IDDM. In Starr County, Texas, all of the male diabetics and all but one of the 285 female diabetics in the age group 25-64 years had NIDDM (Hanis et al. 1983). There are no data available on IDDM rates in younger Hispanic Americans.

PREVALENCE OF NIDDM IN MEXICAN AMERICANS

Perhaps the earliest study of diabetes prevalence in Mexican Americans was carried out in Laredo, Texas, where 17 percent of persons ages 45 to 74 years were found to be diabetic (Table 1), either because they exhibited fasting plasma glucose values exceeding the NDDG criteria for diabetes (greater than or equal to 140 mg/dl) or because they were diagnosed diabetics on insulin or oral antidiabetic medication. Only about 15 percent of the diabetics were newly diagnosed, the remainder having been previously diagnosed as diabetic. This proportion is quite a bit lower than the proportion found in a later study in the San Antonio barrio (an area of socioeconomic status similar to Laredo) and may be due to the fact that OGTTs were not performed in Laredo. Since the sensitivity of the fasting plasma glucose in identifying the total number of diabetics meeting NDDG criteria may only be 59 percent (Haffner et al. 1984), it seems quite possible that there were a number of diabetics in Laredo who might have met the post-load glucose criteria but who were unidentified. The inclusion of such individuals would have generated higher rates of total diabetes and probably also a higher proportion of newly-diagnosed cases in Laredo.

Glucose tolerance tests were performed, however, in a later study conducted in San Antonio. Table 2 shows the prevalence of previously and newly diagnosed NIDDM in Mexican American men and women in San Antonio, and in a random sample of United

TABLE 1. *Prevalence (percent) of diabetes in Mexican Americans in Laredo, Texas, 1979*

Sex and Age (Years)	Previously Diagnosed*		Newly Diagnosed* (Fasting Hyperglycemia)		Total
	Number	Percent	Number	Percent	Percent
Men					
45-54	3/37	8.1	1/37	2.7	10.8
55-64	7/42	16.7	0/42	0	16.7
65-74	5/30	16.7	2/30	6.7	23.3
Total 45-74	15/109	13.8	3/109	2.8	16.5
Age-adjusted prevalence**		13.0		2.7	15.7
Women					
45-54	7/93	7.5	0/93	0	7.5
55-64	9/70	12.9	3/70	4.3	17.1
65-74	18/65	27.7	2/65	3.1	30.8
Total 45-74	34/228	14.9	5/228	2.2	17.1
Age-adjusted prevalence**		14.0		2.2	16.1

*Criteria for previously diagnosed diabetes were history of diabetes together with either fasting plasma glucose ≥ 140 mg/dl or currently using insulin or oral antidiabetic medication; criterion for newly diagnosed diabetes was fasting plasma glucose ≥ 140 mg/dl.

**Age-adjusted by the direct method to the United States 1970 population.

SOURCE: Stern, MP, et al. Cardiovascular risk factors in Mexican Americans in Laredo, Texas. Am J Epidemiol 113:546-555, 1981.

TABLE 2. *Prevalence (percent) of previously and newly diagnosed NIDDM in the San Antonio Heart Study of Mexican Americans, 1979-82, and the Second National Health and Nutrition Examination Survey (NHANES II) of the general United States population, 1976-80*

	San Antonio Age 25-64				NHANES II Whites, Age 20-64	
	Men (N = 551)		Women (N = 737)		Men	Women
	Number	Percent	Number	Percent	Percent	Percent
Previously diagnosed	25	4.5	34	4.6	2.1	3.2
Failed to meet NDDG criteria						
on oral agents	4	0.7	2	0.3		
on insulin	0	0	0	0		
Met NDDG criteria						
on diet only	8	1.5	9	1.2		
on oral agents	11	2.0	16	2.2		
on insulin	2	0.4	7	0.9		
Newly diagnosed*	39	7.1	38	5.2	2.0	3.1
Total	64	11.6	72	9.8	4.1	6.3
Newly diagnosed as percent of total diabetics		61		53	49	49

*All newly diagnosed cases met NDDG criteria for fasting glucose or OGTT values.

TABLE REFERENCES

a. San Antonio data: Haffner, SM, M Rosenthal, HP Hazuda, MP Stern, and LJ Franco. Evaluation of three potential screening tests for diabetes in a biethnic population. Diabetes Care 7:347-53, 1984; and unpublished data.

b. NHANES II data: Harris, MI, National Diabetes Data Group. Unpublished data.

States white men and women from the 1976-80 National Health and Nutrition Examination Survey (NHANES II). The Mexican American rates are consistently higher than the United States rates. Newly diagnosed cases accounted for 61 percent of total cases among Hispanic men and 53 percent among women; they accounted for 49 percent for both men and women in the NHANES II survey. Also shown in Table 2 are the proportion of previously diagnosed Hispanic cases who met the NDDG criteria and the proportions receiving various types of antidiabetic treatment. The proportion of NHANES II previously diagnosed cases that failed to meet NDDG criteria is not known.

Another study, using a somewhat different methodology for ascertaining undiagnosed diabetes, was conducted in Starr County, Texas (Table 3). Like the San Antonio Heart Study and NHANES II, the Starr County study based the diagnosis of newly discovered diabetes on an OGGT using the NDDG criteria. However, Starr County was designed

TABLE 3. *Prevalence (percent) of diabetes in Mexican Americans in Starr County, Texas, 1981*

Sex and Age (Years)	Previously Diagnosed*		Newly Diagnosed*		Total
	Number	Percent	Number	Percent	Percent
Men					
15-24	0/211	0	0/211	0	0
25-34	3/115	2.6	0/115	0	2.6
35-44	3/92	3.3	0/92	0	3.3
45-54	7/95	7.4	5/95	5.3	12.6
55-64	11/85	12.9	3/85	3.5	16.5
65-74	8/60	13.3	2/60	3.3	16.7
75+	4/34	11.8	2/34	5.8	17.6
Total 15-75	36/692	5.2	12/692	1.6	6.9
Age-adjusted prevalence (15-75 yrs)**		5.6		1.9	7.5
Age-adjusted prevalence (25-64 yrs)**		6.2		2.1	8.3
Women					
15-24	1/285	0.4	0/285	0	0.4
25-34	1/254	0.4	0/254	0	0.4
35-44	8/210	3.8	4/210	1.9	5.7
45-54	17/204	8.3	5/204	2.5	10.8
55-64	26/142	18.3	1/142	0.7	19.0
65-74	10/94	10.6	6/94	6.4	17.0
75+	3/50	6.0	1/50	2.0	8.0
Total 15-75	66/1,239	5.3	17/1,239	1.4	6.7
Age-adjusted prevalence (15-75 yrs)**		5.7		1.4	7.1
Age-adjusted prevalence (25-64 yrs)**		7.0		1.3	8.3

*Previously diagnosed diabetes defined as medical history of diabetes, or taking insulin or oral hypoglycemic drugs, or meeting NDDG criteria. Newly diagnosed diabetes defined as all of the following: casual blood glucose ≥130 mg/dl, 4-hour fasting blood glucose ≥130 mg/dl, and meeting NDDG criteria.

**Age-adjusted by the direct method to the United States 1970 population.

SOURCE: Hanis, CL, et al. Diabetes among Mexican Americans in Starr County, Texas. Am J Epidemiol 118:659-72, 1983.

primarily to identify diabetics for a family pedigree study, and two prescreen blood glucose determinations were used to select subjects for the full OGTT. Only subjects who had casual capillary whole blood glucose values greater than or equal to 130 mg/dl were selected for a subsequent 4-hour fasting capillary blood glucose determination. If this fasting value was also greater than or equal to 130 mg/dl (which is greater than the NDDG fasting criteria), glucose tolerance testing was scheduled. Hence ascertainment of undiagnosed diabetics in Starr County was similar to that in Laredo, in that in both a diagnosis of newly discovered diabetes was based primarily on fasting hyperglycemia, and persons with normal fasting values but who might have had abnormal OGTTs appear not to have been included. Thus, as in the Laredo study, the percent of diabetics who were newly diagnosed was markedly lower in Starr County than in San Antonio (20-25 percent versus 50-60 percent), and the rates of total diabetes in Starr County (Table 3) were substantially lower than in the San Antonio barrio (Table 4) (8 percent versus 14 percent for age 25-64 years). The comparison to the barrio is made because Starr County participants, like Laredo participants, were mainly of lower socioeconomic status and were therefore most comparable to San Antonio barrio residents (see below).

TABLE 4. *Prevalence of noninsulin-dependent diabetes mellitus (NIDDM)* in Mexican Americans according to socioeconomic status, the San Antonio Heart Study, 1979-82*

Sex and Age (Years)	Barrio		Transitional Neighborhood		Suburbs	
	Number	Percent	Number	Percent	Number	Percent
Men						
25-34	2/50	4.0	1/62	1.6	0/31	0
35-44	3/32	9.4	4/51	7.8	2/64	3.1
45-54	7/46	15.2	9/40	22.5	7/64	10.9
55-64	15/50	30.0	11/36	30.6	3/25	12.0
Total 25-64	27/178	15.2	25/189	13.2	12/184	6.5
Age-adjusted prevalence**		13.7		14.6		6.1
Women						
25-34	1/71	1.4	1/92	1.1	2/53	3.8
35-44	8/73	11.0	5/65	7.7	1/73	1.4
45-54	13/75	17.3	4/48	8.3	2/54	3.7
55-64	27/79	34.2	7/38	18.4	1/16	6.3
Total 25-64	49/298	16.4	17/243	7.0	6/196	3.1
Age-adjusted prevalence**		14.8		8.2		3.7

*NIDDM defined as cases meeting NDDG criteria for diabetes (fasting or OGTT criteria), or, for those persons who did not meet NDDG criteria, history of diabetes together with current use of insulin or oral antidiabetic agents.

**Age adjusted by the direct method to the United States 1970 population.

SOURCE: Stern, MP , M Rosenthal, SM Haffner, HP Hazuda, and LJ Franco. Sex difference in the effects of sociocultural status on diabetes and cardiovascular risk factors in Mexican Americans. Am J Epidemiol 120:834-51, 1984.

CORRELATION OF DIABETES PREVALENCE WITH SOCIOECONOMIC STATUS AND OBESITY

A distinct socioeconomic gradient for diabetes was found among San Antonio Mexican Americans. The prevalence of NIDDM was more than twice as high among barrio men as among the more affluent suburban men; the prevalence was four times as high among barrio women as among suburban women (Table 4). These results are correlated with the higher prevalence of obesity in the barrio, at least in women (Gardner et al. 1984). However, obesity cannot be the sole explanation for the socioeconomic differences in NIDDM prevalence among Mexican Americans. When lean, average, and obese Mexican Americans are compared to Anglos closely matched for adiposity, Mexican Americans still have from 2 to 3-1/2 times higher NIDDM prevalence than Anglos (Table 5). There is also evidence that the percent of native American genetic admixture (increasing stepwise from suburbs to barrio) may contribute to excess NIDDM prevalence among Mexican Americans (Gardner et al. 1984).

TABLE 5. *Prevalence of noninsulin-dependent diabetes mellitus (NIDDM) according to degree of adiposity, San Antonio Heart Study, 1979-82*

	Men				Women			
	Mexican American		Anglo		Mexican American		Anglo	
Adiposity Category	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Lean	7/87	8.0	1/55	1.8	2/83	2.4	0/73	0
Average	9/128	7.0	2/54	3.7	9/124	7.3	0/77	0
Obese	29/168	17.3	2/56	3.6	47/342	13.7	7/78	9.0
Mantel-Haenszel prevalence ratio		3.59 (p<0.005)				2.30 (p<0.025)		

SOURCE: Stern, MP, SP Gaskill, HP Hazuda, LI Gardner, and SM Haffner. Does obesity explain excess prevalence of diabetes among Mexican Americans? Results of the San Antonio Heart Study. Diabetologia 24:272-77, 1983.

DIABETES AMONG PUERTO RICANS

Diabetes prevalence rates from the Puerto Rico Heart Health Program are summarized in Table 6. In this study, which included men only, the rates of previously diagnosed and newly diagnosed diabetes were considerably higher among urban men than among rural men. Newly diagnosed cases accounted for 42 percent of all rural cases, but only 29 percent of urban cases. Comparing the rates in Puerto Rico to those recorded in San Antonio for corresponding age categories, it is apparent that the highest rates in Puerto Rico (those for urban men) approach the lowest rates in San Antonio (those for suburban men) (Table 4). The monthly income of the Puerto Rican urban men, however, was quite low (Garcia-Palmieri et al. 1970); thus their diabetes rates should be compared with the much higher San Antonio barrio rates. It is difficult to judge if these prevalence differences between Puerto Rico and San Antonio are real since the criteria used to diagnose diabetes in the Puerto Rico study were quite different from those used in the San Antonio Heart Study. In the Puerto Rico study, diabetes was diagnosed if the subject gave a history of this disease (cases treated by diet only were included, in contrast with the procedure followed in San Antonio) or if a casual whole blood glucose was greater than or equal to 140 mg/dl (equivalent to a plasma glucose of 160 mg/dl) by the Somogyi-Nelson method. Although this value is higher than the NDDG fasting cutoff of 140 mg/dl, which would tend to lower the prevalence estimates, the specimens were casual rather than fasting, and the Puerto Rico criteria included cases treated with diet only rather than only those who were receiving antidiabetic medication. Both of these latter procedural differences would tend to raise the prevalence estimates relative to the San Antonio estimates.

Table 6 shows the prevalence of diabetes in Puerto Rican men according to relative weight. As expected, the prevalence rates rose progressively with increasing relative weight both in rural and urban men. Interestingly, at any given relative weight the prevalence of diabetes was higher in urban than in rural men, indicating that although obesity no doubt plays a role in the rural-urban differences, other factors must also be involved. The relative weights in the Puerto Rican Study averaged 1.04 for rural and

TABLE 6. *Prevalence (percent) of previously and newly diagnosed diabetes in Puerto Rican men ages 45 to 64, Puerto Rico Heart Health Program, 1965*

	Rural Men		Urban Men	
	Number	Percent	Number	Percent
Diabetic status				
Previously diagnosed				
Euglycemic		1.3		3.6
Hyperglycemic		0.8		2.8
Newly diagnosed		1.5		2.6
Total		3.6		9.0
Age (years)				
45-49	16/552	2.9	113/1,683	6.7
50-54	24/735	3.3	174/1,935	9.0
55-59	22/684	3.2	134/1,427	9.4
60-64	31/596	5.2	134/1,145	11.7
Total 45-64	93/2,567	3.6	555/6,190	9.0
Age-adjusted prevalence*		3.5		9.0
Relative weight**				
Ages 45-54				
<100	8/545	1.5	21/604	3.5
100-109	2/303	0.7	29/593	4.9
110-125	13/302	4.3	121/1,374	8.8
>125	17/135	12.6	115/1,042	11.0
Ages 55-64				
<100	10/630	1.6	28/592	4.7
100-109	7/279	2.5	40/448	8.9
110-125	23/254	9.1	107/870	12.3
>125	13/115	11.3	93/659	14.1

*Age-adjusted by the direct method to the United States 1970 population.

**Percent of ideal body weight for observed height from Metropolitan Life Insurance tables.

SOURCE: Cruz-Vidal, M, et al. Factors related to diabetes mellitus in Puerto Rican men. Diabetes 28:300-07, 1979.

1.16 for urban men (Cruz-Vidal et al. 1979). In San Antonio, the corresponding figures were 1.12 for barrio men and 1.10 for suburban men. These data suggest that relative leanness might in part explain the lower rates among rural Puerto Ricans relative to barrio San Antonio residents, but not among urban dwellers.

MORTALITY AMONG HISPANIC AMERICANS

Diabetes appears to be a more frequent cause of death among Hispanic Americans than among the general United States population. For example, in Bexar County, Texas (which contains San Antonio), although age-adjusted mortality due to diabetes declined from 1970 to 1976 in both Spanish and non-Spanish surname residents, the rates were consistently two to four times higher in the former than in the latter for both men and women (Figure 1). In the state of Texas in 1970-81, diabetes accounted

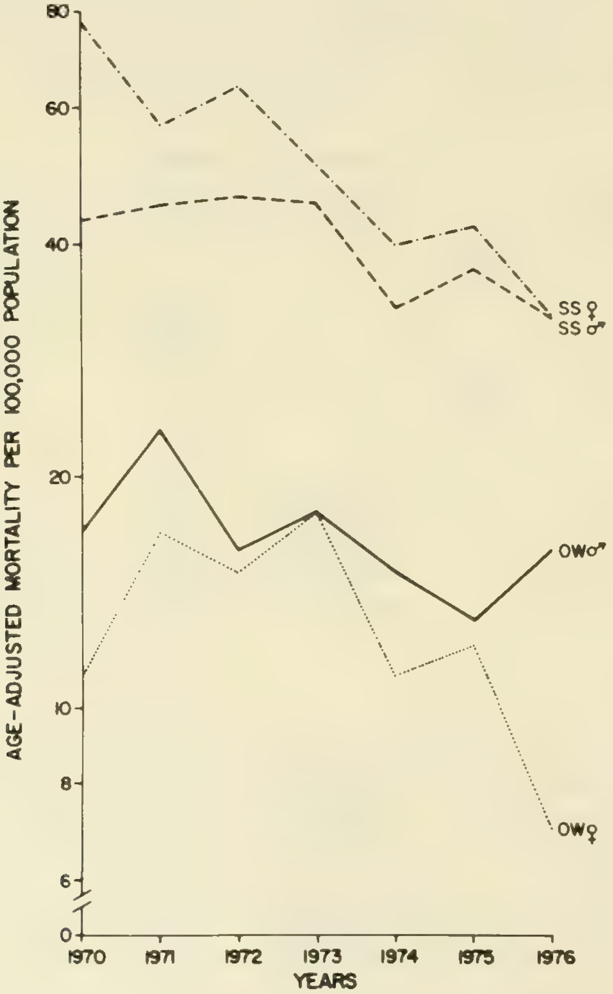

FIGURE 1. *Secular trends in age-adjusted diabetes mortality (ICDA code 250) in Bexar County, Texas from 1970-76 by sex and ethnic group. SS=Spanish surname, OW=other whites.*

SOURCE: Stern, MP, and SP Gaskill. Secular trends in ischemic heart disease and stroke mortality. Circulation 58:537-43, 1978.

for 18.2 per 1,000 deaths, but this proportionate mortality rate in specific counties was highly correlated with the percent of county residents who had Spanish surnames (predominently Mexican American) (Table 7).

TABLE 7. *Diabetes proportionate mortality and percent Spanish origin of residents, Texas, 1970-81*

Area	Diabetes Deaths Per 1,000 Deaths	Percent of Area Residents of Spanish Origin
Texas (state)	18.2	15.4-15.7
Counties		
Starr	52.0	97.9
LaSalle	51.6	78.4
Brooks	45.6	79.9
Webb	43.6	85.6
Maverick	35.5	90.3
Haskell	34.1	13.0
Kleberg	32.1	43.9
Hidalgo	31.5	79.1
Dimmit	31.1	81.7
Mitchell	30.8	24.7
Blanco	8.9	11.2
Brewster	8.3	47.8
Clay	8.3	<5.0
Kendall	7.9	20.3
Brown	7.8	5.4
Red River	7.5	<2.8
Deaf Smith	5.8	36.3
Archer	5.7	<6.9
Somervell	3.8	14.3
Dallam	2.5	17.5

SOURCE: Hanis CL, RE Ferrel, SA Barton, et al. Diabetes among Mexican Americans in Starr County, Texas. Am J Epidemiol 118:659-72, 1983.

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APPENDIX A. *Percent of diagnosed diabetes in Hispanic Americans and the general United States population, 1976*

Age (Years)	All Persons	Hispanic Persons
All ages	2.20	2.13
0-44	0.58	0.54
45-64	4.53	8.48
65-74	8.38	13.44

SOURCE: Harris, MI, and T Drury, National Diabetes Data Group. Unpublished data from the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX B. *Hispanic American population figures*

Hispanic Americans are the second largest and fastest growing minority group in the United States. In 1970, the Hispanic population represented 4.5 percent (9.07 million persons) of the total United States population. In 1980, these figures had grown to 6.4 percent (14.6 million persons). In 1980, nearly 90 percent of United States Hispanics resided in metropolitan areas. More than 3.5 million, or almost one-fourth of all the Hispanics in the country, lived in the Los Angeles and New York City areas alone. The 10 metropolitan areas with the most Hispanics in 1980 were:

Los Angeles-Long Beach, Calif.	2,065,727
New York City-N.J.	1,493,081
Miami, Fla.	581,030
Chicago, Ill.	580,592
San Antonio, Tex.	481,511
Houston, Tex.	424,901
San Francisco-Oakland, Calif.	351,915
El Paso, Tex.	297,001
Riverside-San Bernadino-Ontario, Calif.	289,791
Anaheim-Santa Ana-Garden Grove, Calif.	286,331

SOURCE: U.S. Bureau of the Census.

APPENDIX C. *Spanish origin population of the United States, 1980*

Age (Years)	Males	Females	Age (Years)	Males	Females
All ages	7,278,259	7,327,624	45-49	300,175	321,343
<5	847,860	814,932	50-54	270,030	294,198
5-9	782,641	754,254	55-59	217,123	237,237
10-14	746,936	727,901	60-64	147,184	173,730
15-19	826,449	779,378	65-69	115,542	148,156
20-24	819,158	766,493	70-74	84,748	108,668
25-29	697,098	678,431	75-79	58,927	77,449
30-34	558,146	570,201	80-84	27,371	39,094
35-39	415,640	438,419	85+	18,557	30,273
40-44	344,674	367,467	Median age	22.7	23.8

SOURCE: Bureau of the Census. Age, sex, race, and Spanish origin of the population. Supplementary report PC 80-S1-1, May 1981.

APPENDIX D. *Number of persons (thousands) and percent with Hispanic origin among diabetics and the general population age 20 years and older, United States, 1979-81*

	Age (Years)							
	20+		20-44		45-64		65+	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Both sexes								
Total number of persons*	148,262	5,317	80,810	804	43,529	2,400	23,924	2,112
Number of Hispanic origin	9,044	321	6,061	60	2,176	197	766	64
Percent of Hispanic origin	6.1	6.0	7.5	7.4	5.0	8.2	3.2	3.0
Men								
Total number of men*	69,756	2,306	39,180	326	20,746	1,145	9,830	836
Number of Hispanic origin	4,255	124	2,899	27	1,037	77	315	20
Percent of Hispanic origin	6.1	5.4	7.4	8.3	5.0	6.7	3.2	2.4
Women								
Total number of women*	78,506	3,011	41,630	479	22,782	1,256	14,094	1,276
Number of Hispanic origin	4,710	197	3,122	33	1,139	120	437	44
Percent of Hispanic origin	6.0	6.5	7.5	6.9	5.0	9.6	3.1	3.4

*Excludes persons with unknown origin.

SOURCE: Computed by the Division of Epidemiology and Health Promotion from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

CHAPTER X. DIABETES IN ASIAN AMERICANS

Wilfred Y. Fujimoto, M.D.

SUMMARY

Persons of Asian descent now constitute 1.5 percent of the United States population and number 3.5 million persons. The prevalence of diabetes in this population appears to be higher than among Caucasians in the United States, but the only extensive surveys of diabetes in Asian American populations are of Japanese Americans. Prevalence of asymptomatic hyperglycemia and diabetes among adult male Japanese migrants to the United States is between 10 and 14 percent and is higher than among Japanese living in Japan. Nutrition surveys indicate higher intake of total fat, animal fat, animal protein, and simple carbohydrates and lower intake of total and complex carbohydrates among migrants. The diabetic Japanese population in the United States appears to have a higher prevalence of coronary artery disease, while the native population in Japan exhibits more kidney disease and possibly more eye disease.

INTRODUCTION

The population of Asian Americans in the United States in 1980 was 3.5 million persons, which is a considerable increase over their 1970 prevalence of 1.5 million (Bureau of the Census 1981). Increases in the past several decades have resulted from the large influx of immigrants from China since the late 1960s; from Korea, the Philippines, and India since the early 1970s; and the recent influx from Southeast Asia (Immigration 1979). Asian Americans are concentrated in the West (59 percent), with 1.3 million in California and 0.6 million in Hawaii; 0.3 million reside in New York. The Asian American population can be expected to continue to increase, as their birth rate is considerably higher than that of whites or blacks in the United States (30 percent versus 8 percent and 7 percent) (Taffel 1984).

PREVALENCE OF DIABETES AMONG ADULTS

Studies of diabetes in Asian American populations have been extensively reported only for Japanese Americans, with the exception of a study of Asians on Oahu, Hawaii, in 1958-59 (Sloan 1963). For 38,103 employed persons from various ethnic groups and

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labor classes on Oahu, comprising about 30 percent of the civilian work force, finger blood samples were obtained 2 to 2 1/2 hours after a meal containing at least 50 grams of carbohydrate. Persons with blood glucose levels greater than 130 mg/dl were referred to their physicians, who were asked to determine whether the subject was or was not diabetic, to report the methods and criteria used in diagnosis, and to indicate whether the diagnosis had been previously known. Age-adjusted prevalence rates for diabetes among the various Asian groups were considerably greater than among Caucasians (Table 1).

TABLE 1. *Prevalence of diabetes among pure Caucasians and Asians on Oahu, Hawaii, 1958-59*

Race	Number Screened	Number With Diabetes			Diabetes Rate/1,000 Persons*	
		Total	New	Known	Total	New
Total	38,103	819	492	327	18.4	11.0
Caucasian	4,473	49	32	17	7.3	4.8
Chinese	3,755	67	45	22	14.6	10.3
Filipino	4,321	150	99	51	21.8	15.5
Japanese	16,134	307	200	107	20.1	12.6
Korean	539	10	8	2	19.7	11.7

*Age-adjusted rates; the standard population used was the Oahu civilian labor force, 14 years of age or older in 1950.

SOURCE: Sloan, NR. Ethnic distribution of diabetes mellitus in Hawaii. JAMA 183:419-24, 1963.

It appears that the prevalence of asymptomatic hyperglycemia plus diabetes among Japanese American adult males is between 10 and 14 percent, and that the prevalence among Japanese migrants is higher than among Japanese living in Japan.

The prevalence of known diabetes among Japanese employees ages 40 years and older of the Nippon Telephone and Telegram Public Corporation in Tokyo in 1973 was 2.8 percent, while in those 50 years of age or older it was 4.9 percent (Toyota et al. 1976) (Table 2). Since the prevalence of diabetes among male employees was nearly four times greater than among females, and since nearly six times as many males as females were surveyed, the actual prevalence of diabetes in the Japanese population at large was probably lower. The rates for the United States in 1976 were comparable to the rates for males in the Tokyo study. The rates for Japanese males were higher than for females, illustrating an apparent preponderance of diabetes in Japanese males.

The most extensive study of diabetes among Japanese migrants to the United States has been the Hiroshima University Study (Kawate et al. 1979, 1980). Surveys of Japanese migrants who were originally from Hiroshima prefecture and their offspring were conducted on the island of Hawaii in 1973, 1976, and 1978 (n = 892 subjects) and in Los Angeles in 1978 (n = 257). Japanese living in agricultural areas of Hiroshima prefecture were surveyed in 1975 and 1978 (n = 779); selection of rural rather than urban areas of Hiroshima prefecture was based on the knowledge that the majority of Japanese migrants to the United States came from rural Japanese areas. Prevalence of diabetes was ascertained from either known treatment with insulin or oral hypoglycemic agents, or serum glucose levels greater than or equal to 200 mg/dl at 2 hours

TABLE 2. *Age-specific prevalence of diabetes in Tokyo, 1973, and United States, 1976*

Age (Years)	Number of Tokyo Diabetic Patients*/Total (Percent) Males	Females	Both Sexes	U.S.** Percent
20-29	13/16,225 (0.08)	1/3,514 (0.03)	14/19,739 (0.07)	0.6
30-39	48/8,896 (0.5)	7/1,498 (0.5)	55/10,394 (0.5)	1.1
40-49	206/8,657 (2.4)	8/1,067 (0.7)	214/9,724 (2.2)	2.6
50-59	110/2,129 (5.2)	3/230 (1.3)	113/2,359 (4.8)	4.8
60-69	17/246 (6.9)	0/30 (0)	17/276 (6.2)	7.1
20-69	394/36,153 (1.1)	19/6,339 (0.3)	413/42,492 (1.0)	-

*Subjects under treatment for diabetes.

**Self-reported physician-diagnosed diabetes rates for both sexes combined.

SOURCE: Toyota, T, M Kudo, Y Goto, S Taya, and K Komatsu. Prevalence of diabetes mellitus in rural and urban populations in Japan. In: Baba, S, Y Goto, and I Fukui, eds. Diabetes Mellitus in Asia. Amsterdam: Excerpta Medica, 1976. pp. 35-40; and data from the 1976 National Health Interview Survey, National Center for Health Statistics.

after a 50-gram oral glucose load. Age-sex-obesity-adjusted prevalence rates for diabetes in 1978 when surveys were conducted in all three locations were 13.3 percent (n = 453) in Hawaii, 11.0 percent (n = 257) in Los Angeles, and 5.8 percent (n = 336) in Hiroshima. Prevalence rates in Hawaii and Los Angeles were not significantly different from each other, whereas the rate in Hiroshima was significantly lower (p less than 0.01). The age- and sex-specific prevalence rates for diabetes over the full study periods show that the rate among Japanese Americans was twice the rate among native Japanese (Table 3). Higher rates among migrants were found even when comparisons were made on the basis of matched body mass index (BMI), and thus differences could not be attributed to obesity. A male preponderance was not observed.

In the Ni-Hon-San Study, three Japanese male populations were examined in Japan, Honolulu, and eight San Francisco Bay area counties (Kagan et al. 1974). In Japan, the study group was a 20 percent sample of a population of approximately 100,000 persons under study by the Atomic Bomb Casualty Commission. This was an ambulatory population composed of persons receiving general biennial examinations since 1958, some of whom had been exposed to radiation and some who had not. In Honolulu, the study group was identified through World War II Selective Service records from among 14,426 men of pure Japanese ancestry born in 1900-1919 and resident on Oahu in 1965; of these, 11,148 were located and 9,878 men were studied. California subjects were persons born in Japan who had immigrated to the United States before 1925 (Issei) and their children (Nisei), selected from a roster of Japanese American households drawn from a variety of sources; 3,809 men ages 30-69 years were examined. They included 2,974 of 4,480 eligible men residing in eight San Francisco Bay area counties and 835 Japanese men from Santa Clara County. Greater glucose intolerance was observed 1 hour after a 50-gram oral glucose load among both migrant Japanese populations than among the population residing in Japan (Table 4). The Hawaii and California groups were similar except for the two older age groups (60-64 and 65-69 years) in which glucose levels of the California men were intermediate between men in Hawaii and Japan. This difference may be accounted for by the fact that, in California, glucose was not given to men with known diabetes.

TABLE 3. *Prevalence rates of diabetes* in Japanese Americans, 1973-78, and native Japanese, 1975-78*

Sex and Age (Years)	Hawaii and Los Angeles (1973-78)			Hiroshima (1975-78)		
	Number of Subjects	Number Diabetic	Percent Diabetic	Number of Subjects	Number Diabetic	Percent Diabetic
Male						
15-39	53	0	0	12	1	8.3
40-59	159	16	10.1	138	4	2.9
60-96	284	55	19.4	158	12	7.6
All	496	71	14.3	308	17	5.5
Female						
15-39	70	4	5.7	28	0	0
40-59	254	25	9.8	210	10	4.8
60-96	329	69	21.0	233	24	10.3
All	653	98	15.0	471	34	7.2
Both sexes						
15-39	123	4	3.3	40	1	2.5
40-59	413	41	9.9	348	14	4.0
60-96	613	124	20.2	391	36	9.2
All	1,149	169	14.7	779	51	6.5
Age- and sex-adjusted rate			13.9			6.5

*Serum glucose $\geq$ 200 mg/dl at 2 hours after 50-gram oral glucose load, or under treatment with insulin or oral hypoglycemic agent.

SOURCE: Kawate, R, M Yamakido, and Y Nishimoto. Migrant studies among the Japanese in Hiroshima and Hawaii. In: Waldhausel, WK, ed. Diabetes 1979, Proceedings of the 10th Congress of the International Diabetes Federation. Amsterdam: Excerpta Medica, 1980. pp. 526-31.

TABLE 4. *Mean serum glucose (mg/dl) 1 hour after an oral 50-gram glucose load in Japanese and Japanese American men*

Age (Years)	Japan	Oahu	California*
45-49	137.4	150.3	155.3
50-54	147.8	158.8	154.6
55-59	139.9	164.1	162.7
60-64	146.8	173.4	158.7
65-69	152.7	182.1	171.3

*In California, glucose was not given to men with known diabetes.

SOURCE: Kagan, A, BR Harris, W Winkelstein, et al. Epidemiologic studies of coronary heart disease and stroke in Japanese men living in Japan, Hawaii and California. J Chron Dis 27:345-64, 1974.

Death certificate data also indicate that higher diabetes prevalence exists in Japanese migrants to the United States than in Japanese remaining in Japan (Table 5). However, diabetes death rates in Hawaiian Japanese and in Japanese remaining in Japan have increased between 1952 and 1977 (while those for Hawaiian Caucasians have declined), indicating that the rate of diabetes in persons of Japanese descent may be increasing.

TABLE 5. *Proportion of deaths attributed to diabetes as the underlying cause of death on death certificates in Hawaii and Japan*

Hawaii, Number/Total Number (Percent)			Japan, Number/Total Number (Percent)	
Years	Japanese	Caucasians	Years	Japanese
1952-59	42/1,529 (2.7)	37/516 (7.2)	1955	2,191/693,089 (0.3)
1960-69	95/1,662 (5.7)	49/798 (6.1)	1965	5,115/700,237 (0.7)
1970-77	115/1,164 (9.9)	42/714 (5.9)	1975	9,032/702,281 (1.3)

SOURCE: Kawate, R, M Yamakido, Y Nishimoto, PH Bennett, RF Hamman, and WC Knowler. Diabetes mellitus and its vascular complications in Japanese migrants on the island of Hawaii. Diabetes Care 2:161-70, 1979; and vital statistics of Japan for 1955, 1965, and 1975.

In the Nisei Aging Project in Seattle, a random sample of Japanese Americans age 50 years or older (n = 80, 49 males and 31 females) was generated from a mailing list of 98 percent of the total Japanese population of the greater Seattle area; 85 percent of those contacted participated in the survey. Subjects were persons of pure Japanese ancestry who immigrated to the United States before the age of 6 years and prior to 1925, and persons of pure Japanese ancestry born in the United States of at least one parent who had immigrated to the United States after the age of 6 years and prior to 1925. The age range was 50-72 years (mean 60 years). Among males, 10.2 percent self-reported diabetes as an illness or physical problem experienced during the year preceding the survey, while 3.2 percent of the females reported diabetes (Leonetti 1983). In a more recent survey conducted by the Japanese American Community Diabetes Study of a larger random sample of the same population, 12.1 percent of 214 men and 8.1 percent of 174 women reported they had diabetes (Fujimoto and Leonetti 1984). Of 45 men (age 50-70 years) who believed they did not have diabetes and underwent a 75-gram oral glucose tolerance test, 51 percent were normal (fasting serum glucose less than 115 mg/dl and 2-hour serum glucose less than 140 mg/dl), 13 percent were diabetic (fasting serum glucose greater than 140 mg/dl and/or 2-hour serum glucose greater than 200 mg/dl), and 36 percent had impaired glucose tolerance (2-hour serum glucose greater than or equal to 140 mg/dl and less than 200 mg/dl).

The Honolulu Heart Program included men of Japanese ancestry born in 1900 to 1919 and living on Oahu, Hawaii, in 1965. Of 11,148 eligible men located, 8,006 participated in the initial examination during 1965 to 1968, and 7,916 men ages 45-68 years had a 1-hour 50-gram oral glucose tolerance test. Known diabetes was present in 5.9 percent of participants, while an additional 6.7 percent had 1-hour serum glucose levels greater than or equal to 225 mg/dl and were considered to have asymptomatic hyperglycemia (Table 6). Thus a total of 12.6 percent of the population had glucose intolerance. Rates of known diabetes in all United States males were about one-half those in Japanese American males in two comparable age groups (Table 6).

PREVALENCE OF CHILDHOOD-ONSET DIABETES

Prevalence of childhood-onset diabetes among Japanese has been reported to be from about 1-13 per 100,000 (Baba and Morita 1980), compared to about 1 per 600 children in the United States.

NUTRITION

Nutrition surveys were conducted by the Hiroshima University Study in Hiroshima in 1975, and in Hawaii and Los Angeles in 1976 and 1978. The intake of total fat, animal fat, animal protein, and simple carbohydrate was higher and that of total carbohydrate and complex carbohydrate was lower in migrant Japanese than in those in Japan (Table 7). Total energy intake, adjusted for obesity (BMI) and physical activity, was similar.

TABLE 6. *Age distribution of glucose intolerance among 7,916 Japanese American men in Hawaii, 1965-68*

	Known Diabetics		Asymptomatic Hyperglycemia**		Normoglycemia***	
Age (Years)	Number	Percent*	Number	Percent	Number	Percent
45-49	57	3.1	116	6.4	1,642	90.5
50-54	162	5.9	179	6.5	2,420	87.6
55-59	113	7.2	107	6.8	1,359	86.0
60-64	101	7.7	91	6.9	1,128	85.4
65-68	35	7.9	40	9.1	366	83.0
45-68	468	5.9	533	6.7	6,915	87.4

*Comparable figures for Japanese American and all United States males in 1965-68 are: ages 45-54, 4.8 percent and 2.1 percent; ages 55-64, 7.4 percent and 3.9 percent.

**Serum glucose ≥ 225 mg/dl at 1 hour after 50-gram oral glucose load.

***Persons not meeting above glucose criteria and with no medical history of diabetes.

SOURCE: Yano, K, A Kagan, D McGee, and GG Rhoads. Glucose intolerance and 9-year mortality in Japanese men in Hawaii. Am J Med 72:71-80, 1982.

TABLE 7. *Mean daily dietary intake of Japanese Americans and native Japanese, 1975-78*

	Hawaii and Los Angeles, 1976-78		Hiroshima, 1975	
	Males	Females	Males	Females
Number of persons studied	502	580	188	241
Total energy (calories)	2,147	1,707	2,258	1,930
Protein (grams)	95	78	74	67
Percent animal protein	68.4	67.9	50.0	50.7
Fat (grams)	72	59	43	41
Percent animal fat	54.2	50.8	44.2	41.5
Carbohydrate (grams)	257	211	349	314
Percent simple carbohydrate	33.5	37.0	10.3	12.1

SOURCE: Kawate, R, M Yamakido, and Y Nishimoto. Migrant studies among the Japanese in Hiroshima and Hawaii. In: Waldhausel, WK, ed. Diabetes 1979, Proceedings of the 10th Congress of the International Diabetes Federation. Amsterdam: Excerpta Medica, 1980. pp. 526-31.

These dietary data are similar to those in the Ni-Hon-San Study (Kagan et al. 1974) and in a pilot study of Japanese American men in Seattle and Japanese men in Tokyo with NIDDM (Table 8).

TABLE 8. *Mean daily dietary intake of Japanese Americans and native Japanese men*

	Ni-Hon San Study, 1965-70*			Seattle-Tokyo Study, 1979-81**	
	Japan	Hawaii	California	Seattle	Tokyo
Total daily energy intake (calories)	2,132	2,274	2,268	1,970	1,984
Percent protein	14.3	16.7	16.3	17.3	17.9
Percent animal protein	-	-	-	66.9	54.9
Percent fat	15.1	33.2	37.6	41.4	24.2
Percent animal fat	-	-	-	55.1	47.8
Percent carbohydrate	63.2	46.4	44.1	39.4	51.0
Percent alcohol	8.7	3.7	2.5	2.0	6.6
Cholesterol (mg)	467	545	536	401	449

*Based upon 24-hour diet recall interview.

**Based upon 3-day diet diary.

TABLE REFERENCES

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Seattle-Tokyo Pilot Study: Fujimoto, WY, K Hershon, J Kinyoun, et al. Type II diabetes mellitus in Seattle and Tokyo. Tohoku J Exp Med 141(Suppl):133-39, 1983.

COMPLICATIONS ASSOCIATED WITH DIABETES

In the Hiroshima University Study, the prevalence of complications associated with diabetes and its risk factors was studied among Hawaii and Hiroshima subjects. Hypercholesterolemia, hypertriglyceridemia, hypertension, and treatment for ischemic heart disease were more prevalent in Hawaiian Japanese diabetics than in Hiroshima diabetics (Table 9). Prevalence of proteinuria was 50 percent greater in Hawaii, although this difference was not statistically significant. Prevalence of retinopathy was similar in both groups, but it has also been reported that both retinopathy and proteinuria occurred more frequently among diabetics in Japan than in England (Bennett and Miller 1976).

In the Seattle-Tokyo Diabetes Pilot Study, more Seattle Nisei diabetic men than Tokyo diabetic men had plasma cholesterol levels greater than or equal to 250 mg/dl (33 percent versus 5 percent) and Seattle men had higher mean plasma cholesterol levels than Tokyo men (239 ± 7 versus 195 ± 10 mg/dl, p less than 0.01). Tokyo men had lower creatinine clearance rates (110 ± 4 versus 77 ± 3 ml/min, p less than 0.001). More Tokyo men had diabetic retinopathy but fewer had ischemic electrocardiographic abnormalities than Seattle men (Fujimoto et al. 1983).

In the Honolulu Heart Program, many cardiovascular risk factors were found to be associated with glucose intolerance, including obesity, hypertension, and higher serum cholesterol and triglyceride levels (Yano et al. 1982). By taking into account the confounding effects of these risk factors, the post-load (1 hour after ingestion of 50 grams of glucose) serum glucose level remained a significant risk factor for death from all causes, all cardiovascular causes (8th ICD Code 390-458), and coronary heart disease.

The proportion of deaths due to vascular disease in diabetics was similar in Japanese American and Caucasian diabetic populations in Hawaii during 1952-57 (Table 10), but

TABLE 9. *Clinical findings in Japanese American and Japanese diabetic subjects age 40+ years*

	Hawaii	Hiroshima	p Value
Number of persons studied	106	351	-
Male:female ratio	43:63	139:212	-
Age in years (mean ± standard deviation)	67.0 ± 9.6	60.5 ± 10.6	-
Serum cholesterol ≥ 250 mg/dl	32.3%	21.9%	<0.05
Serum triglyceride ≥ 150 mg/dl	53.8%	32.5%	<0.005
Systolic blood pressure ≥ 160 mm Hg, diastolic blood pressure ≥ 95 mm Hg	39.6%	28.8%	<0.005
Ischemic heart disease: Either one or a combination of I-1, IV-1 to 3, and V-1 to 4 classified by the Minnesota code	27.4%	20.5%	Not sig.
Treatment for ischemic heart disease	9.4%	1.1%	<0.005
Proteinuria	13.2%	8.8%	Not sig.

SOURCE: Kawate, R, M Yamakido, Y Nishimoto, PH Bennett, RF Hamman, and WC Knowler. Diabetes mellitus and its vascular complications in Japanese migrants on the Island of Hawaii. Diabetes Care 2:161-70, 1979.

TABLE 10. *Percent of deaths due to vascular disease on death certificates of deceased Caucasian and Japanese American diabetics in Hawaii, age 40+ years, 1952-77*

Vascular Disease	Caucasians (N=128)	Japanese Americans (N=251)
Brain	18.0	21.9
Ischemic heart	32.8	32.7
Other cardiac	15.6	8.8
Renal	8.6	10.6
Total vascular disease	75.8	74.5

SOURCE: Kawate, R, M Yamakido, Y Nishimoto, PH Bennett, RF Hamman, and WC Knowler. Diabetes mellitus and its vascular complications in Japanese migrants on the Island of Hawaii. Diabetes Care 2:161-70, 1979.

was about 50 percent lower in Japan in 1968-70 than in Hawaii (Table 11). This difference was attributable to relatively fewer deaths due to ischemic heart disease in Japan (Tables 10 and 11). However, recent data are noteworthy for changes in causes of death in Japan, with sizable increases in deaths due to malignant neoplasm and ischemic heart disease (Table 11).

TABLE 11. *Percent of deaths due to certain primary causes on death certificates of diabetics in Japan and the United States*

	Japan (a) (N = 1,885)	Tokyo, Japan (b) (N = 106)	U.S. (c) (N = 96,847)
Death Certificate Cause	1968-1970	1976-1979	1978
Diabetic coma	9.8	0	3.0
Cardiovascular disease	51.1	53.8	75.9
Brain	18.4	16.1	12.2
Ischemic heart	9.7	21.7	42.3
Renal	16.1	9.4	5.8
Other	6.9	6.6	15.6
Malignant neoplasms	14.2	26.4	6.9
Liver cirrhosis	5.4	7.6	-
Infections	9.4	2.8	4.8
Other	10.1	9.4	9.4

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b. Mihara, T, H Ohashi, and Y Hirata. A prospective study of 1,629 diabetics in Tokyo. In: Melish, JS, J Hanna, and S Baba, eds. Genetic Environmental Interaction in Diabetes Mellitus. Amsterdam: Excerpta Medica, 1982.

c. Harris, MI, National Diabetes Data Group. Diabetes as an underlying and contributing cause of death. Unpublished data.

In summary, the migrant diabetic Japanese population in the United States has a higher prevalence of ischemic heart disease, while the native population in Japan exhibits more renal disease and possibly more retinopathy. The role of environmental factors must be considered in the genesis of these differences as well as in the greater prevalence of diabetes in Japanese Americans. Differences in nutrient intake appear to be one highly likely reason. Particularly relevant may be the lower consumption of carbohydrate calories and a proportionally greater consumption of fat, and a greater consumption of animal fat and protein by Japanese Americans than by native Japanese. These differences have been consistently observed in other studies and may be related to the greater prevalence of diabetes, hypercholesterolemia, and ischemic heart disease in the Japanese American population. Also to be considered is the psychosocial stress experienced by the Japanese American population as it underwent tremendous socioeconomic changes during the periods of immigration, assimilation, relocation during World War II, and postwar rebuilding of their economic independence. The importance of sociocultural factors, such as retention of native customs and support systems, also requires elucidation.

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APPENDIX A. *Prevalence of Asian Americans in the United States, 1980*

	Prevalence		Regional Prevalence (Thousands)			
	Number (Thousands)	Percent	West	South	North Central	Northeast
Chinese	806	23.0	425	91	73	218
Filipino	775	22.1	537	83	80	75
Japanese	701	20.0	565	45	44	47
Asian Indian	362	10.3	72	84	85	121
Korean	355	10.1	154	70	62	68
Vietnamese	262	7.5	120	80	37	25
Hawaiian	167	4.8	148	11	5	4
Samoan	42	1.2	38	2	1	1
Guamanian	32	0.9	23	5	2	2
Total	3,501	100.0	2,081	470	390	560

Percent of U.S. population = 1.5

SOURCE: Bureau of the Census. Race of the Population by States, 1980. Supplementary Report, July 1981.

APPENDIX B. *Age-adjusted race-mortality ratios for specific causes of death, United States, 1980**

Cause of Death	Chinese	Japanese	Filipino
Heart disease	0.54	0.42	0.42
Cancer	0.76	0.60	0.40
Cerebrovascular disease	0.76	0.76	0.66
Accidents	0.34	0.44	0.39
Chronic obstructive pulmonary disease	0.50	0.34	0.31
Pneumonia and influenza	0.81	0.73	0.59
Diabetes mellitus	0.81	0.64	0.49
Chronic liver disease and cirrhosis	0.42	0.34	0.29
Atherosclerosis	0.57	0.41	0.25
Suicide and self-inflicted injury	0.64	0.62	0.30

*Ratios are calculated for each specific cause of death by dividing the age-adjusted death rate of a specified ethnic group by the age-adjusted death rate of the white population.

SOURCE: National Center for Health Statistics, published and unpublished death certificate data.

APPENDIX C. *Rank order and percent of total deaths for the 10 leading causes of death, United States, 1980*

			White		Chinese		Japanese		Filipino	
Rank	Cause of Death	ICD-9 Codes	Rank	%	Rank	%	Rank	%	Rank	%
1	Heart disease	390-398,402,404-429	1	39.3	1	31.8	1	30.4	1	33.5
2	Cancer	140-208	2	21.3	2	27.4	2	25.4	2	20.5
3	Cerebrovascular disease	430-438	3	8.6	3	8.6	3	11.2	3	10.1
4	Accidents	E800-E949	4	5.2	4	4.2	4	5.4	4	6.7
5	Chronic obstructive pulmonary disease	490-496	5	3.0	6	2.4	8	2.0	6	2.0
6	Pneumonia and influenza	480-487	6	2.6	5	3.0	5	3.5	5	2.8
7	Diabetes mellitus	250	7	1.7	8	2.1	7	2.0	7	1.8
8	Chronic liver disease and cirrhosis	571	8	1.4	9	1.2	9	1.2	9	1.2
9	Atherosclerosis	440	9	1.5	10	0.9	10	1.0	10	0.6
10	Suicide & self-inflicted injury	E950-E959	10	1.5	7	2.2	6	2.3	8	1.5

SOURCE: National Center for Health Statistics, published and unpublished death certificate data.

APPENDIX D. *Age-adjusted nativity-mortality ratios for 10 leading causes of death, United States, 1980**

Rank	Cause of Death	Chinese	Japanese	Filipino
1	Heart disease	1.98	3.04	2.67
2	Cancer	2.41	2.82	1.63
3	Cerebrovascular disease	2.93	4.21	2.76
4	Accidents	2.13	2.94	2.29
5	Chronic obstructive pulmonary disease	3.31	2.88	1.75
6	Pneumonia and influenza	2.29	4.37	2.92
7	Diabetes mellitus	1.52	2.09	2.42
8	Chronic liver disease and cirrhosis	2.50	4.95	2.06
9	Atherosclerosis	2.75	6.38	0.93
10	Suicide and self-inflicted injury	2.71	2.69	1.15

*Ratios are calculated by dividing the age-adjusted death rate of the foreign-born by the age-adjusted rate of the native-born population from the same ethnic group.

SOURCE: National Center for Health Statistics, published and unpublished death certificate data.

CHAPTER XI. DIABETES IN NORTH AMERICAN INDIANS

Maurice L. Sievers, M.D., and Jeffrey R. Fisher, M.D.

SUMMARY

Currently about 1.5 million persons of American Indian, Eskimo (Inuit or Innuit), or Aleut origin reside in the United States; 96 percent are American Indians. Until the 1930's diabetes mellitus occurred quite infrequently among North American Indians (West 1974, Sievers and Fisher 1981), but during the last 50 years the diagnosis of diabetes has become progressively more common in most Indian population groups. In some tribes diabetes had achieved epidemic proportions by the 1960's, but in other tribal groups the increases in prevalence have been more modest. Concomitantly, obesity has also assumed epidemic proportions in most Native American populations. A startling 50 percent of Pima Indians over age 35 have diabetes (Knowler et al. 1981)—the highest known rate for any population group—and several tribes have prevalence rates among adults greater than 20 percent. In full-heritage Indians, diabetes is almost exclusively the noninsulin-dependent, ketosis-resistant type (NIDDM), with the same manifestations and vascular complications as in non-Indians. With the exception of some Athabascan tribes and the Eskimos (West 1974, Mouratoff et al. 1969, Mouratoff and Scott 1973), diabetes has become a major cause of morbidity and mortality in most North American native populations (Sievers and Fisher 1981). The extent of Indian heritage, tribe, parental diabetes, HLA-A2, and 1.5 kb DNA insertion of the 5' flanking region of the insulin gene have all been associated with diabetes in Indians. These associations provide evidence for a genetic component to NIDDM. Obesity appears to be a significant environmental factor influencing the future risk of diabetes.

DIABETES PREVALENCE

A summary of most of the published findings regarding diabetes prevalence in North American Indians and Eskimos since 1940 is presented in Table 1. The studies are listed by tribe and region in chronological order. Within each tribe, therefore, some inferences about time trends may be made, but the validity of such implications is limited by variations in study methods and diagnostic criteria, both of which have tended to become more stringent in recent years. The tabular data were derived from the references cited in Table 1, but in a few instances minor corrections have been

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TABLE 1. *Reported prevalence of diabetes mellitus among North American Indians and Eskimos, by tribe, age group, and years of study*

Reference	Tribe and Location	Years of Study	Study Method*	Diagnostic Criteria**	Age Group (Years)	Study Population (Number of Persons)			Diabetes Mellitus [Percent (and Number) of Persons]		
						Males	Females	Both	Males	Females	Both
	SOUTHWEST										
a	Pima (Arizona)	1940	B-3	F	All	-	-	4,633	-	-	0.5(21)
b		1950-52	B-3	E	All	1,152	1,746	2,895	2.7(32)	3.5(62)	3.2(94)
c		1955	B-2	E	≥15	3,418	3,557	6,975	3.3(113)	4.9(169)	4.0(282)
d		1958-65	B-1	B	≥20	-	-	-	-	-	45.0(-)
e		1965-69	A-1	B	≥5	1,358	1,559	2,917	16.1(219)	21.7(339)	19.1(558)
					≥15	811	955	1,766	26.8(217)	33.9(324)	30.6(541)
					≥35	437	461	898	41.0(279)	58.1(268)	49.8(447)
f		1965-79	A-1	A+	≥5	2,000	2,126	4,126	16.2(324)	18.8(400)	17.5(724)
					≥15	1,249	1,379	2,628	25.9(324)	28.9(399)	27.5(723)
					≥35	592	618	1,210	43.4(257)	55.3(342)	49.5(599)
a	Papago (Arizona)	1940	B-3	F	All	-	-	4,055	-	-	0.3(10)
b		1950-52	B-3	E	All	723	1,181	1,904	0.8(6)	0.1(2)	0.4(8)
d		1958-65	B-1	B	≥20	-	-	-	-	-	33.0(-)
g		≤1976	A-4	B	≥35	-	-	365	-	-	42.2(154)
h	Papago and Yaqui (Arizona)	1981	B-3	E	All	-	-	16,230	-	-	9.2(1490)
					≥35	-	-	9,236	-	-	26.7(1132)
i	Maricopa (Arizona)	1966	A-2	B	≥15	-	-	186	-	-	29.8(49)
d	Hopi (Arizona)	1958-65	B-1	B	≥20	-	-	-	-	-	9.0(-)
j		1963-65	B-2	E	All	1,470	1,530	3,000	0.3(4)	1.2(19)	0.8(23)
					≥15	823	857	1,680	0.5(4)	2.2(19)	1.4(23)
					≥30	470	490	960	0.9(4)	3.9(19)	2.4(23)

TABLE 1. (Continued)

Reference	Tribe and Location	Years of Study	Study Method*	Diagnostic Criteria**	Age Group (Years)	Study Population (Number of Persons)			Diabetes Mellitus [Percent (and Number) of Persons]		
						Males	Females	Both	Males	Females	Both
d	Haulapai-Havasupai (Arizona)	1958-65	B-1	B	≥20	-	-	-	-	-	28.0(-)
b	Yuma (Arizona and California)	1950-52	B-3	E	All	221	256	477	4.5(10)	1.9(5)	3.1(15)
k	Upland Yumans: Hualapai, Havasupai, Yavapai, (Arizona)	1970	A-4	B	All ≥35	133 41	168 60	301 101	6.0(8) 19.5(8)	19.0(32) 50.0(30)	13.3(40) 37.6(38)
l	Cocopah (Arizona)	1969	A-1	B	≥15 ≥35	50 35	73 44	123 79	20.0(10) 25.7(9)	27.4(20) 40.9(18)	24.4(30) 34.2(27)
b	Mojave (Arizona and California)	1950-52	B-3	E	All	611	816	1,427	2.9(18)	1.7(14)	2.2(32)
m	Cauhilla and Luiseno (California)	≤1970	A-4	F	All	35	61	96	-	-	12.5(12)
b	Paiute and Shoshone (Nevada)	1950-52	B-3	E	All	1,107	1,329	2,436	1.0(11)	0.8(10)	0.9(21)
n	Paiute (Nevada)	1970	A-2	B	≥15 ≥35	66 27	65 27	131 54	7.6(5) 18.5(5)	15.4(10) 33.3(9)	11.5(15) 25.9(14)
n	Washoe (Nevada and California)	1970	A-2	B	≥15 ≥35	50 34	62 32	112 66	6.0(3) 8.8(3)	14.5(9) 25.0(8)	10.7(12) 16.7(11)
b	Ute (Utah)	1950-52	B-3	E	All	331	546	877	1.8(6)	0.9(5)	1.2(11)
d		1958-65	B-1	B	≥20	-	-	-	-	-	7.0(-)

TABLE 1. (Continued)

Reference	Tribe and Location	Years of Study	Study Method*	Diagnostic Criteria**	Age Group (Years)	Study Population (Number of Persons)			Diabetes Mellitus [Percent (and Number) of Persons]		
						Males	Females	Both	Males	Females	Both
o	Zuni (New Mexico)	≤1970	A-4	B	≥35	-	-	292	-	-	31.5(92)
p		1975-76	B-3	E	All	3,133	3,170	6,303	4.1(128)	4.4(139)	4.3(267)
					≥25	982	1,045	2,027	12.8(137)	13.1(137)	13.0(263)
					≥45	428	328	756	20.6(88)	30.2(99)	24.7(187)
a	Apache (Arizona)	1940	B-3	F	All	-	-	4,906	-	-	0.2(12)
b	San Carlos Apache (Arizona)	1950-52	B-3	E	All	932	1,171	2,103	0.2(2)	0.3(7)	0.4(9)
g		≤1976	A-4	B	≥35	-	-	317	-	-	24.9(79)
b	Whiteriver Apache (Arizona)	1950-52	B-3	E	All	1,017	1,149	2,266	0.2(3)	0.0(0)	0.1(3)
o		≤1970	A-4	B	≥35	-	-	268	-	-	10.8(29)
a	Navajo (Arizona)	1940	B-3	F	All	-	-	36,176	-	-	0.01(4)
d		1958-65	B-1	B	≥20	-	-	-	-	-	1.0(-)
q		1958-63	B-2	B	All	8,603	8,954	17,557	0.5(47)	0.6(58)	0.6(105)
					≥20	5,592	5,820	11,412	0.8(47)	1.0(58)	0.9(105)
					≥40	1,807	1,880	3,687	2.0(37)	2.7(51)	2.4(88)
j		1963-65	B-2	B	All	7,350	7,650	15,000	0.5(35)	0.6(43)	0.5(78)
					≥20	4,116	4,284	8,400	0.8(34)	1.0(43)	0.9(77)
					≥30	2,352	2,448	4,800	1.4(33)	2.1(42)	1.6(76)
					≥40	1,543	1,607	3,150	1.6(25)	1.9(30)	1.7(55)
o		≤1970	A-4	B	≥35	-	-	55	-	-	12.7(7)
	ALASKA										
r	Athabascan	≤1969	A-4	B	≥20	152	154	306	1.3(2)	2.6(4)	2.0(6)
r	(Alaska)	≤1969	A-4	A	≥20	152	154	306	0.0(0)	2.0(3)	1.0(3)

TABLE 1. (Continued)

Reference	Tribe and Location	Years of Study	Study Method*	Diagnostic Criteria**	Age Group (Years)	Study Population (Number of Persons)			Diabetes Mellitus [Percent (and Number) of Persons]		
						Males	Females	Both	Males	Females	Both
h	Alaska IHS Area: (Athabascans, Haida, Tlingits, Tsimshians, Eskimos, and Aleuts)	1981	B-3	E	All	-	-	64,047	-	-	0.9(550)
					≥35	-	-	16,716	-	-	2.9(488)
s	Eskimos (Alaska)	1962	A-4	B	≥20	378	327	705	0.5(2)	7.0(23)	3.5(25)
					≥40	153	133	286	0.7(1)	6.1(8)	3.1(9)
				A	≥20	350	309	659	0.0(0)	1.3(4)	0.6(4)
s		1972	A-4	B	≥20	140	180	320	5.0(7)	9.4(17)	7.5(24)
					≥40	96	96	192	5.2(5)	10.3(10)	7.8(15)
	SOUTHERN										
t	Seminole (Oklahoma)	1963	A-4	D	≥14	121	181	302	6.7(8)	11.6(20)	9.3(28)
					≥30	81	124	205	8.6(7)	13.7(17)	11.7(24)
u	Seminole (Florida)	1969	A-2	C,D	All	49	69	118	14.3(7)	17.4(12)	16.1(29)
					≥20	20	32	52	35.0(7)	34.4(11)	34.6(18)
					≥35	-	-	37	-	-	37.8(14)
v	Seminole and Creek (Oklahoma)	≤1974	A-4	A+	≥30	-	-	89	-	-	19.1(17)
w	Cherokee (North Carolina)	1965	A-3	B	≥35	210	238	448	26.7(56)	31.1(74)	29.0(130)
v	Cherokee (Oklahoma)	≤1974	B-2	F	≥35	-	-	4,000	-	-	13.3(530)
v		≤1974	A-4	C	≥30	-	-	124	-	-	20.2(25)
x	Choctaw (Oklahoma)	1956-61	B-2	B	All	1,572	2,003	3,575	4.1(64)	3.5(71)	3.8(135)
					≥30	651	874	1,525	9.7(63)	8.1(71)	8.8(134)
v		≤1974	B-2	F	≥35	-	-	2,900	-	-	17.2(500)
y	Pawnee (Oklahoma)	1965	B-2	E	All	-	-	2,241	-	-	11.6(262)
					≥20	-	-	1,031	-	-	24.6(254)

TABLE 1. (Continued)

Reference	Tribe and Location	Years of Study	Study Method*	Diagnostic Criteria**	Age Group (Years)	Study Population (Number of Persons)			Diabetes Mellitus [Percent (and Number) of Persons]		
						Males	Females	Both	Males	Females	Both
z	"Plains Indians"+ (Oklahoma)	1951-55	B-2	E	All	4,889	5,089	9,978	2.8(139)	5.7(291)	4.3(430)
v	Apache and Kiowa-Apache (Oklahoma)	≤1974	B-2	E	"Adults"	-	-	130	-	-	7.7(10)
v	Chickasaw (Oklahoma)	≤1974	B-2	F	≥35	-	-	2,300	-	-	13.5(310)
v	Cheyenne-Arapaho (Oklahoma)	≤1974	B-2	F	≥35	-	-	1,000	-	-	19.5(195)
v	Kickapoo (Oklahoma)	≤1974	B-2	F	≥30	-	-	173	-	-	16.2(28)
v	Sauk and Fox (Oklahoma)	≤1974	B-2	F	≥30	-	-	-	-	-	16.0(-)
v	Shawnee (Oklahoma)	≤1974	B-2	F	≥30	-	-	-	-	-	19.0(-)
v	Kiowa and Comanche (Oklahoma)	≤1974	A-4	B	≥30	-	-	80	-	-	13.8(11)
v	Comanche (Oklahoma)	≤1974	A-4	F	≥30	-	-	1,200	-	-	12.2(146)
aa	Alabama-Coushatta (Texas)	1959-63	A-2	D	All ≥20	300 125	300 145	600 270	6.3(19) 15.2(19)	14.9(42) 29.0(42)	10.2(61) 22.6(61)
	MIDWESTERN										
bb	Sioux and Assiniboine (Montana)	≤1969	B-2	E	All	1,715	1,785	3,500	3.2(55)	2.5(45)	2.9(100)

+Indian population studied said to be largely Kiowa, Comanche, Apache, and the Five Civilized Tribes (Cherokee, Choctaw, Chickasaw, Creek, and Seminole)

TABLE 1. (Continued)

Reference	Tribe and Location	Years of Study	Study Method*	Diagnostic Criteria**	Age Group (Years)	Study Population (Number of Persons) Males	Study Population (Number of Persons) Females	Study Population (Number of Persons) Both	Diabetes Mellitus [Percent (and Number) of Persons] Males	Diabetes Mellitus [Percent (and Number) of Persons] Females	Diabetes Mellitus [Percent (and Number) of Persons] Both
cc	Mandan, Arickara, Hidatsa--"Three Affiliated Tribes" (North Dakota)	1978	B-2	E	All	-	-	2,842	-	-	6.2(175)
					≥35	-	-	877	-	-	17.7(155)
	NORTHEASTERN										
dd	Passaquoddy (Maine)	1965	A-1	E	≥20	-	-	56	-	-	14.3(8)
ee	Seneca (New York)	1967	A-3	D	≥25	85	122	207	28.2(24)	32.8(40)	30.9(64)

*Meaning of the symbols used:

A. Population Study: Percent of Population Studied

- A-1. ≥75%
- A-2. 50%-74%
- A-3. 25%-49%
- A-4. ≤24%

B. Hospital or Clinic Study

- B-1. With screening tests
- B-2. Chart review only
- B-3. Other, less stringent

**Meaning of the symbols used (post-load refers to 75-gm glucose, although in a few instances some variation occurred):

A+. Equivalent to 2-hour post-load plasma glucose ≥200 mg/dl

A. Equivalent to 2-hour post-load plasma glucose ≥180 mg/dl (or ≥160 mg/dl, whole blood)

B. Equivalent to 2-hour post-load plasma glucose ≥160 mg/dl

C. Equivalent to 2-hour post-load plasma glucose ≥140 mg/dl

D. Other blood glucose values (fasting, postprandial, or post-load), less stringent

E. "Previous diagnosis" (with or without criteria stated)

F. Criteria not stated (or only a test of urine for glucose)

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made in published rates. For example, when the figure given for percent with diabetes differed from that calculated from the listed number with diabetes (divided by the population), the percent was changed. Similarly, the published percent was changed when calculation from the percent given did not yield a whole number of persons (i.e., when only the population number and the percent with diabetes were published, if calculation of the number with diabetes did not produce a whole number, then the rounded-off whole number was used; and, correspondingly, the percent was corrected to reflect this change). A few population estimates that were not listed in the publications were available from other sources, and these figures have been included when appropriate.

The Pima Tribe of Arizona has been studied more intensely and carefully than any other population group. Since 1940, this tribe appears to have experienced a progressive increase in the prevalence of diabetes. Indeed, between 1967 and 1977, using stringent criteria for defining diabetes, there was a 42 percent increase in diabetes prevalence (Table 2). The increase occurred for both sexes and in each age group except the youngest (Figure 1). In Table 1, the last two sets of data for the Pima are based on studies from 1965-69 and 1965-79. Although more stringent diagnostic criteria ("A+") were used for the latter period, the prevalence rate for each age group and both sexes was similar to that for the earlier period with "B" diagnostic criteria. Fortuitously, the marked increase in the prevalence of diabetes in the Pima population between 1969 and 1979 (Table 2) compensated for a subsequent relative reduction in the number of persons classified as diabetic by the enhanced criteria.

In addition to the Pima, other tribes with reported diabetes prevalence rates of 20 percent or greater among adults (35 years old or older) include the Papago (Sievers 1966, Bennett et al. 1976, Justice 1983), Upland Yuman (Hualapai, Havasupai, and Yavapai) (Sievers 1966, Smith 1970), Maricopa (Justice 1967), San Carlos Apache (Bennett et al. 1976), and Cocopah (Henry et al. 1969) of Arizona; the Zuni (Bennett 1972) of New Mexico; the Paiute (Bartha 1973) of Nevada; the Seminole (Westfall and Rosenbloom 1971) of Florida; the Cherokee (Stein et al. 1965) of North Carolina; the Cherokee (West 1974), and Pawnee (White 1966) of Oklahoma; the Alabama-Coushatta (Johnson and McNutt 1964) of Texas; the Seneca (Doeblin et al. 1969) of New York; and, presumably, the Cheyenne-Arapaho, Shawnee, Seminole, and Creek (West 1974) of Oklahoma.

DEGREE OF INDIAN HERITAGE

Among the more than 432 North American Indian tribes, of which at least 391 live in the United States (Swanton 1952), considerable racial homogeneity exists as evidence of their Mongoloid origin. However, the Eskimo, Aleut, and Indians of the Na-Dene language group (including the Navajos and Apaches) are more recent migrants to North America, and each is genetically distinct from the other Native Americans, who comprise most of the tribes of North America.

TABLE 2. *Increased prevalance of diabetes* in Pima Indians ages 5 years and older, 1967-77*

Sex	Age-adjusted Rate (±SE)/100 Persons** 1967	Age-adjusted Rate (±SE)/100 Persons** 1977	Percent Change
Males	20.0(1.4)	31.6(1.9)	+58
Females	27.6(1.6)	36.3(1.8)	+38
Both	24.0(1.1)	34.1(1.3)	+42

*Criterion for diabetes = 2-hour post 75-gm glucose of ≥ 200 mg/dl

**The 1970 United States population used as standard population

SOURCE: Bennett, PH, and WC Knowler. Increasing prevalence of diabetes in the Pima (American) Indians over a ten-year period. (International Congress Series No. 500.) In: Diabetes 1979, Excerpta Medica Foundation, 1980, Amsterdam.

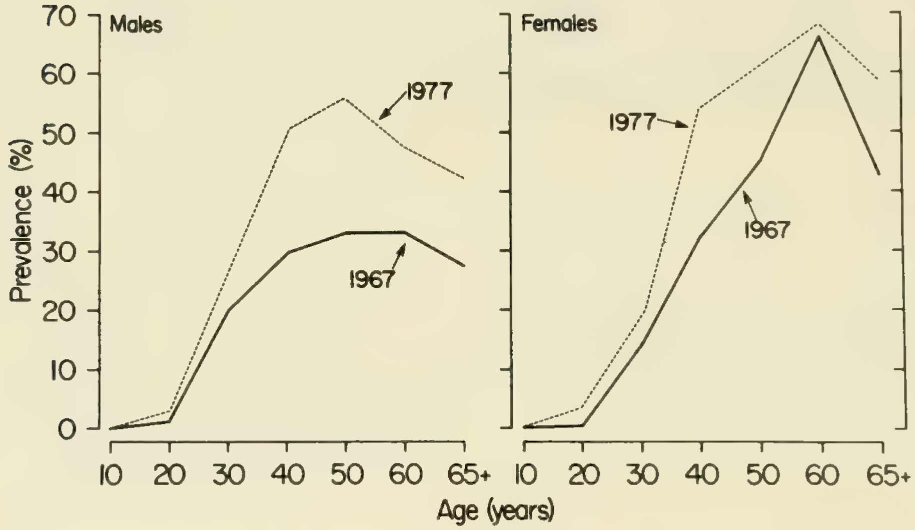

FIGURE 1. *Age-specific prevalence of diabetes in Pima Indians, 1967 and 1977*

SOURCE: Bennett, PH, and WC Knowler. Increasing prevalence of diabetes in the Pima (American) Indians over a ten-year period. (International Congress Series No. 500.) In: Diabetes 1979, Excerpta Medica Foundation, 1980, Amsterdam.

Among genetically closely related tribes, the rates of diabetes in adults (35 years old or older) may be similar, as for the Piman group—the Pimas (50 percent) and Papagos (42 percent) of Arizona, both of whom live on arid desert reservations—or may differ widely, as for the Athabascan group—the San Carlos Apaches (25 percent), Whiteriver Apaches (11 percent), Navajos (13 percent), and Athabascans of Alaska (approximately 3 percent). Indeed, among the Alaska Athabascans, the rate of diabetes is closer to that for the genetically unrelated Eskimos of that Arctic region than it is to the rates for the three Athabascan tribes of the more temperate Southwest.

Table 3 presents data on the effect of degree of Indian heritage on the incidence rates of diabetes in two tribes. In all age categories, except the oldest males, the rates were higher for Pimas than for full-heritage Choctaws. Variations of the methods and periods of study probably did not account for all of this difference. In the Choctaws the incidence rate in full-heritage Indians was higher for all age groups, except the older one, than in Indians with less than full but more than half Indian heritage.

Additional evidence that the extent of Indian heritage is related to diabetes prevalence rates is presented in Table 4. The Choctaws of Oklahoma, the Cherokees of North Carolina, and the Three Affiliated Tribes of North Dakota live in very different environments, but in each tribe diabetes is less prevalent in the group with least Indian heritage. For the Cherokees, the diabetes rate was high for each of the three groups with half or greater Indian quantum; but for the Three Affiliated Tribes, the rate was significantly lower for persons age 35 years or older who were less than full but greater than half Indian (14.9 percent) than for those of full Indian ancestry (22.3 percent). In Figure 2, diabetes incidence by sex and decade of age is compared for full and mixed (half or greater Choctaw heritage) Choctaw Indians.

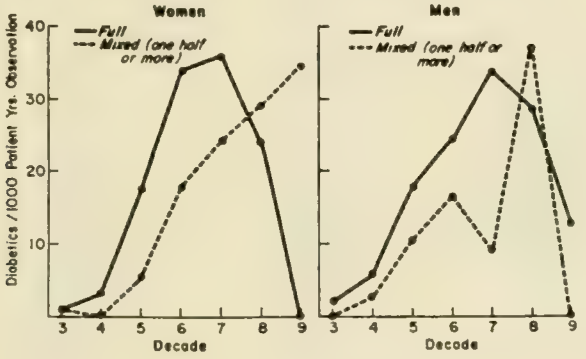

FIGURE 2. *Incidence of diabetes in Choctaw Indian women and men of full and mixed (half or greater Choctaw) ancestry, by decade of age, 1956-61*

SOURCE: Drevets, CC. Diabetes mellitus in Choctaw Indians. J Okla State Med Assoc 58:324, 1965.

TABLE 3. *Reported incidence rates of diabetes among the Choctaw and the Pima Indians, by age group and putative quantum Indian heritage*

					Full Heritage Indian (Cases/1,000 Person-Years)			<Full, >1/2 Indian (Cases/1,000 Person-Years)		
Reference	Tribe and Location	Years of Study	Study Method and Diagnostic Criteria	Age Group (Years)	Males	Females	Both	Males	Females	Both
a	Choctaw (Oklahoma)	1956-61	Chart review of 831 male and 1,162 female full-bloods, and 741 male and 847 female half-to-full-bloods; plasma glucose ≥160 mg/dl 2 hours after 75-gm glucose	0-19	0.0	0.0	0.0	0.0	0.0	0.0
				20-29	1.9	0.9	1.1	0.0	1.0	0.7
				30-39	6.3	3.3	4.0	2.7	0.0	0.8
				40-49	18.4	18.6	18.4	10.7	5.7	7.8
				50-59	24.4	34.5	29.9	16.7	18.8	17.9
				60-69	33.7	36.0	31.9	9.0	24.5	17.8
				70-89	25.3	18.9	21.6	32.9	33.3	31.4
				Total Person-Years:	5,690.7	10,098.9	15,789.6	3,132.2	3,201.9	6,334.1
b	Pima (Arizona)	1965-75	Complete population study; 90.5% have full Indian heritage; plasma glucose ≥200 mg/dl 2 hours after 75-gm glucose	5-14	0.4	0.4	0.4			
				15-24	12.4	9.8	10.8			
				25-34	48.3	45.2	46.2			
				35-44	60.9	56.4	58.0			
				45-54	24.5	63.9	46.0			
				55-64	37.2	47.2	41.8			
				65-94	20.8	31.9	26.0			
				Total Person-Years:	5,472	7,155	12,627			

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TABLE 4. *Reported prevalence rates of diabetes among North American Indians, by tribe, age group, years of study, and putative quantum Indian heritage*

Reference	Tribe and Location	Years of Study	Study Method and Diagnostic Criteria*	Age Group (Years)	Indian Quantum (In Eighths)	Study Population (Number of Persons) Males	Study Population (Number of Persons) Females	Study Population (Number of Persons) Both	Diabetes Mellitus [Percent (and Number) of Persons] Males	Diabetes Mellitus [Percent (and Number) of Persons] Females	Diabetes Mellitus [Percent (and Number) of Persons] Both
a	Choctaw (Oklahoma)	1956-61	Chart review; plasma glucose ≥160 mg/dl 2 hours post 75-gm glucose	All	8/8	831	1,162	1,993	5.7(47)	5.1(59)	5.3(106)
					<8/8,>1/8	741	841	1,582	2.3(17)	1.4(12)	1.8(29)
				≥30	8/8	433	587	1,020	10.6(46)	10.1(59)	10.3(105)
					<8/8,>1/8	218	287	505	7.8(17)	4.2(12)	5.7(29)
b	Cherokee (North Carolina)	1965	Study of 1/4 to 1/2 of population; plasma glucose ≥160 mg/dl 2 hours post 75-gm glucose	≥35	8/8	-	-	154	-	-	29.2(45)
					<8/8, ≥6/8	-	-	105	-	-	36.2(38)
					<6/8, ≥4/8	-	-	43	-	-	41.9(18)
					<4/8, ≥2/8	-	-	34	-	-	8.8(3)
					<2/8	-	-	30	-	-	20.0(6)
					≥4/8	-	-	302	-	-	33.4(101)
					≤4/8	-	-	64	-	-	14.1(9)
					Unknown	-	-	82	-	-	24.4(20)
c	Mandan, Arikara, and Hidatsa--"Three Affiliated Tribes" (North Dakota)	1978	Chart review of persons with a previous diagnosis of diabetes	≤34	8/8	-	-	1,145	-	-	0.7(8)
					<8/8,>4/8	-	-	885	-	-	0.7(6)
					≤4/8	-	-	812	-	-	0.7(6)
					None						
				≥35	8/8	-	-	537	-	-	22.3(120)
					<8/8,>4/8	-	-	194	-	-	14.9(29)
					≤4/8	-	-	146	-	-	4.1(6)
					None	-	-	97	-	-	4.1(4)
d	Pima and Papago (Arizona)	1965-82	Complete population studied; plasma glucose ≥200 mg/dl 2 hours post 75-gm glucose	≥35	8/8	645	662	1,307	46.7(301)	57.7(382)	52.3(683)
					<8/8,>4/8	3	13	16	33.3(1)	46.2(6)	43.8(7)
					≤4/8	7	5	12	28.6(2)	60.0(3)	41.7(5)
					None	13	3	16	7.7(1)	0 (0)	6.3(1)

*Most but not all subjects were studied by these methods and criteria.

TABLE REFERENCES

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OBESITY, FAMILY HISTORY OF DIABETES, AND GENETIC FACTORS

The prevalence of diabetes in the Pima Tribe increased 42 percent between 1967 and 1977 (Table 2). During this period, the Pimas also became more obese, with weight gain being greatest for persons below 35 years of age (Table 5). That these two events are related is suggested by longitudinal studies indicating that the more obese a Pima was initially, the higher the future risk of diabetes (Figure 3).

It is well known that NIDDM is familial, and this finding has been confirmed for the Pimas (Hamman et al. 1978). Figures 4 and 5 show that obesity and family history have synergistic effects on the incidence of diabetes. Parental diabetes also appears to have a long-term effect on the weight of the offspring. Indeed, at 15 to 19 years of age, obesity of 140 percent or more of desirable weight occurred in 58 percent of offspring of Pima diabetics but in only 25 percent of offspring of prediabetics and 17 percent of those of nondiabetics (Pettit et al. 1983).

The prevalence of the leucocyte antigen HLA-A2 is higher at all ages in Pima diabetics (59 percent at age 55) than in Pima nondiabetics (39 percent) (Williams et al. 1981). In addition, 1.5 kb DNA insertion in the 5' flanking region of the insulin gene is associated (p = 0.01) with noninsulin-dependent diabetes in unrelated Pima Indians and in blacks and whites (Rotwein et al. 1983). These associations provide evidence for a genetic component to NIDDM in Pimas.

TABLE 5. *Average changes in mean body weight, percent desirable weight (PDW), and body mass index (BMI)* in Pima Indians age 15 years and older during the 10-year period between 1967 and 1977*

	Average Changes Between 1967 and 1977				
Sex and Age (Years)	Weight (kg)	P-Value	PDW	BMI*	P-Value
Males					
15-24	9.24	<.001	10.57	2.57	<.001
25-34	8.58	<.01	10.89	2.69	<.01
35-44	3.41	NS	4.84	1.13	NS
45-54	3.33	NS	2.57	0.62	NS
55-64	1.84	NS	0.81	0.25	NS
≥65	0.87	NS	1.37	0.32	NS
Females					
15-24	6.56	<.001	10.57	2.17	<.001
25-34	5.62	<.01	9.32	1.91	<.01
35-44	0.93	NS	-0.09	-0.04	NS
45-54	4.26	<.05	4.10	0.71	NS
55-64	5.37	<.05	8.61	1.78	<.05
≥65	-1.03	NS	-3.63	-0.83	NS

*BMI = (body weight in kg)/(height in m)^2

SOURCE: Bennett, PH, and WC Knowler. Increasing prevalence of diabetes in the Pima (American) Indians over a ten-year period. (International Congress Series No. 500.) In: Diabetes 1979, Excerpta Medica Foundation, 1980, Amsterdam.

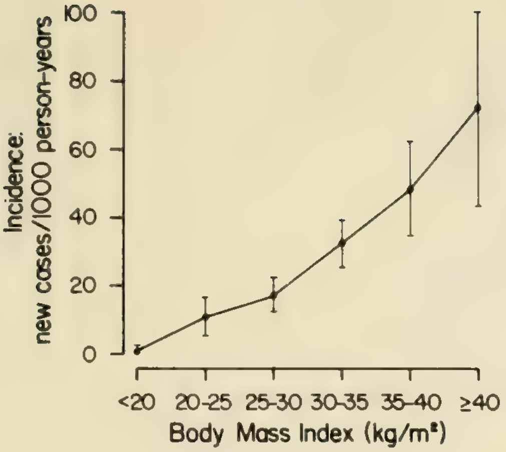

FIGURE 3. *Age-sex adjusted incidence rates (with 95 percent confidence intervals, i.e., ± 1.96 standard errors) for diabetes in Pima Indians, by body mass index*

SOURCE: Knowler, WC, DJ Pettit, PJ Savage, and PH Bennett. Diabetes incidence in Pima Indians: Contributions of obesity and parental diabetes. Am J Epidemiol 113(2):149, 1981.

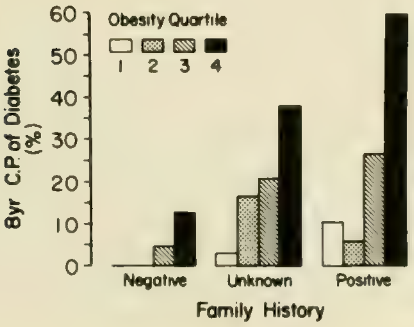

FIGURE 4. *Eight-year cumulative probability (CP) of Pimas developing diabetes by family history (at least one parent having diabetes) and body mass index quartile (1=16.16-24.242; 2=24.243-28.089; 3=28.090-32.526; 4=32.527-52.861).*

SOURCE: Hamman, RF, PH Bennett, and M Miller. Incidence of diabetes among the Pima Indians. Adv Metab Disord 9:61, 1978.

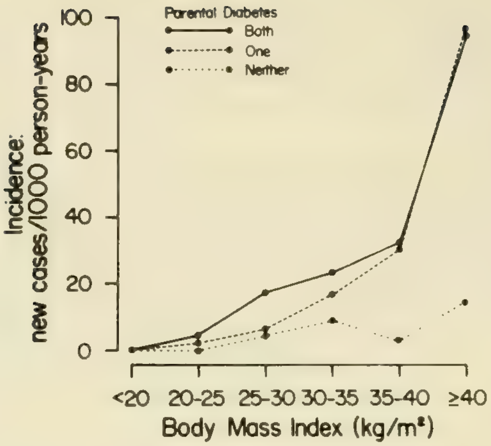

FIGURE 5. *Age-adjusted incidence of diabetes in Pima Indians ages 5-44 years, by parental diabetes status as determined by glucose tolerance testing and body mass index*

SOURCE: Knowler, WC, DJ Pettitt, PJ Savage, and PH Bennett. Diabetes incidence in Pima Indians: Contributions of obesity and parental diabetes. Am J Epidemiol 113(2):152, 1981.

COMPLICATIONS OF DIABETES

Diabetes increases the otherwise low rate of coronary artery disease in southwestern Indians (Sievers and Fisher 1981). The 6-year incidence of retinopathy and of heavy proteinuria (an index of the presence of nephropathy) in Pima Indians, according to initial 2-hour plasma glucose concentrations, is shown in Figure 6. These complications developed in a much higher proportion of persons with hyperglycemia than occurred in those with euglycemia. About half of all deaths from vascular causes in Pima diabetics were attributed to diabetic nephropathy (Bennett and Miller 1976). American Indians, as compared to other United States population groups, appear to have end-stage renal disease more frequently, probably as a consequence of the high rates of diabetes in many tribes (Sievers and Fisher 1981). The number of Indians requiring renal dialysis has expanded rapidly. Among American Indians, the age-adjusted mortality for diabetes was 2.1 times the rate for all United States races (USDHEW 1978).

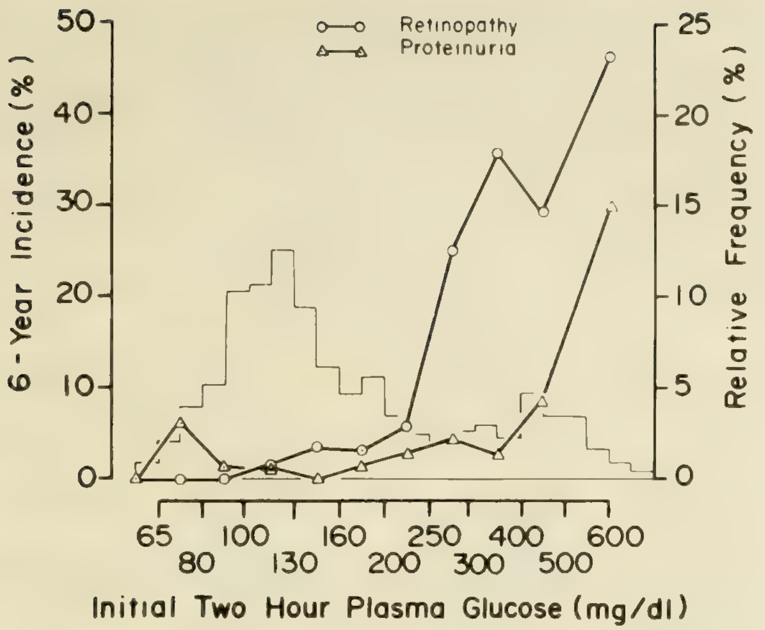

FIGURE 6. *Incidence of retinopathy and heavy proteinuria (urine protein/ creatinine ratio greater than or equal to 1.0) over a 6-year period, according to initial two-hour plasma glucose concentrations (histogram), in Pima Indians*

SOURCE: Bennett, PH, WC Knowler, DJ Pettitt, MJ Carraher, and B Vasquez. Longitudinal studies of the development of diabetes in the Pima Indians. (INSERM Symposium No. 22.) In: Eschwege, E, ed. Advances in diabetes epidemiology. Amsterdam: Elsevier Biomedical Press, 1982.

IMPLICATIONS

Among many Indian tribes of North America, diabetes has attained epidemic proportions. Diabetic complications are major causes of morbidity and mortality in most Native American populations. The basic disease and its deleterious long-term effects are similar in all ethnic groups. Factors in the causation and complications of diabetes and the principles of management appear to be generally applicable to all races. Extensive innovative efforts are needed to interrupt the increasing prevalence of diabetes among North American Indians.

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APPENDIX A. *Number of American Indians, Eskimos, and Aleuts, by age and sex, United States, 1980*

Age (Years)	Males	Females	Age (Years)	Males	Females
All	701,007	717,188	45 to 49	27,885	30,117
Under 5	75,669	73,334	50 to 54	24,987	26,600
5 to 9	73,988	72,376	55 to 59	21,440	23,352
10 to 14	78,920	76,811	60 to 64	15,970	17,911
15 to 19	86,069	83,992	65 to 69	12,781	15,475
20 to 24	74,788	74,197	70 to 74	8,818	11,068
25 to 29	61,432	63,330	75 to 79	6,084	7,658
30 to 34	52,318	54,695	80 to 84	2,862	4,190
35 to 39	41,015	42,993	85 and over	2,295	3,557
40 to 44	33,686	35,532	Median age	22.4	23.5

SOURCE: Bureau of the Census. 1980 Census of the population, race of the population by States. Report PC80-51-3. July 1981.

APPENDIX B. *Number of American Indians, Eskimos, and Aleuts, by state of residence, United States, 1980*

States	American Indian	Eskimo	Aleut
New England			
Maine	4,057	17	13
New Hampshire	1,297	41	14
Vermont	968	8	8
Massachusetts	7,483	129	131
Rhode Island	2,872	14	12
Connecticut	4,431	68	34
Middle Atlantic			
New York	38,117	330	285
New Jersey	8,176	130	88
Pennsylvania	9,173	153	133
East North Central			
Ohio	11,986	167	87
Indiana	7,681	107	47
Illinois	15,833	242	196
Michigan	39,702	208	128
Wisconsin	29,318	110	69
West North Central			
Minnesota	34,841	118	67
Iowa	5,367	59	27
Missouri	12,127	119	73
North Dakota	20,119	32	6
South Dakota	45,081	17	3
Nebraska	9,147	26	24
Kansas	15,254	81	36
South Atlantic			
Delaware	1,309	13	8
Maryland	7,823	113	85
District of Columbia	996	19	16
Virginia	9,093	156	87
West Virginia	1,555	37	18
North Carolina	64,519	57	59
South Carolina	5,666	70	22
Georgia	7,444	108	67
Florida	18,981	199	136
East South Central			
Kentucky	3,518	59	33
Tennessee	5,012	62	29
Alabama	7,483	50	28
Mississippi	6,131	28	21
West South Central			
Arkansas	9,346	48	17
Louisiana	11,950	59	55
Oklahoma	169,297	107	60
Texas	39,374	395	305
Mountain			
Montana	37,153	79	38
Idaho	10,418	76	27
Wyoming	7,088	27	10
Colorado	17,726	235	98
New Mexico	104,634	88	55
Arizona	152,610	138	109
Utah	19,158	81	17
Nevada	13,201	74	29
Pacific			
Washington	58,159	1,251	1,361
Oregon	26,587	407	315
California	198,095	1,734	1,482
Alaska	21,849	34,135	8,063
Hawaii	2,664	68	46
United States Total	1,361,869	42,149	14,177

SOURCE: Bureau of the Census. 1980 Census of the population, race of the population by States. Report PC80-51-3. July 1981.

CHAPTER XII. DIABETIC KETOACIDOSIS, HYPEROSMOLAR NONKETOTIC COMA, LACTIC ACIDOSIS, AND HYPOGLYCEMIA

Howard A. Fishbein, Dr.P.H.

SUMMARY

Having diabetes mellitus requires daily self-management. When management is insufficient, certain acute metabolic derangements may occur that can precipitate life-threatening situations. This chapter reviews four of these metabolic states: diabetic ketoacidosis (DKA), hyperosmolar nonketotic coma (HNC), lactic acidosis (LA), and hypoglycemia. It is generally recognized that, if these conditions are promptly identified, they can usually be successfully treated. However, the etiology of these conditions has been insufficiently researched, and their relationship to the development of diabetic complications is unknown. A necessary step lies in understanding the epidemiology of these conditions in order to develop and implement preventive measures. The key findings to date on these conditions are:

DKA Incidence

- The annual incidence of DKA ranges from 3-8 episodes per 1,000 diabetics.
- DKA episodes occur at onset of diabetes in 20-30 percent of newly diagnosed diabetics.
- Noncompliance with diet/medication and infection precipitate at least 50 percent of DKA episodes.
- The DKA rate in females is about 1.5 times that in males.

DKA Hospitalizations

- Approximately 75,000 hospitalizations for DKA occur each year.
- Two to fourteen percent of all diabetic hospital admissions are for DKA.
- As a proportion of all diabetic hospitalizations, DKA is highest in young diabetics (0-19 years).
- The largest number of DKA admissions occurs in diabetics ages 15-44 years, compared to 0-14, 45-64, or 65+ years.

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- The direct hospitalization cost for DKA admissions is estimated at $120,000,000 annually in the United States.
- Prevention of unnecessary DKA admissions could potentially save $113 million annually.

DKA Mortality

- DKA is the cause of 9-10 percent of deaths due to diabetes as the underlying cause each year.
- When rates from 1930-1959 are compared to those from 1960-1975, DKA mortality has decreased.
- Average DKA mortality is estimated at 57/100,000 diabetics per year.
- DKA mortality in females is about 50 percent higher than in males.
- The percent of diabetic deaths due to DKA is about three times higher for nonwhites than for whites.

Other Conditions

- Most cases of HNC occur in elderly diabetics.
- Fatality from HNC is estimated at 40-50 percent.
- The frequency and epidemiology of lactic acidosis and hypoglycemia have not been well documented.

DIABETIC KETOACIDOSIS

Introduction

Of the four conditions considered in this chapter, diabetic ketoacidosis (DKA) accounts for the greatest number of hospitalizations and deaths, has received the most attention by researchers, and is perhaps the most preventable. Early investigators recognized that patients with poor control of their diabetes excrete ketones in the urine and develop DKA (Naunyn 1900, Gerhardt 1865, Hallervorden 1879). Before insulin was commercially available, DKA was reported as accounting for 74 percent of all diabetes-associated deaths (Paz-Guevara et al. 1975). Currently, approximately 8.3 percent of deaths in which diabetes is the underlying cause of death are attributed to DKA. Deaths not complicated by severe cardiovascular or renal conditions should be preventable, since onset of DKA is usually accompanied by recognizable symptoms occurring over a period of hours to a few days. Recognition of these symptoms by a knowledgeable diabetic could lead to rapid medical intervention to prevent the development of severe acidosis (Benson and Matz 1979, Schade and Eaton 1979, Clements and Vourganti 1978). Hospitalization rates and mortality from DKA may reflect patient and provider action, and the incidence of DKA might serve as an index of the quality of medical care (Rutstein et al. 1976).

Incidence of DKA

In the population-based study of all Rochester, Minnesota diabetics diagnosed during 1945-70, 92 episodes of DKA occurred among 1,536 diabetics. The DKA incidence rate was 8 per 1,000 person-years of study (one diabetic studied for one year equals one person-year) (Johnson et al. 1980). DKA incidence among diabetics diagnosed below age 30 years was 13.4 per 1,000 person-years; among diabetics diagnosed at 30 years or older, the incidence was 3.3 per 1,000 person-years. In the study of all Rhode

Island hospital admissions in 1979-80, the incidence of DKA was estimated at 4.6 per 1,000 diabetics per year (Table 1). The rates were highest in the youngest age group, and they were 50 percent higher for female diabetics than for male diabetics. In addition, incidence rates for patients admitted from nursing homes were strikingly high (Table 1).

TABLE 1. *Diabetic acidosis rates estimated from all admissions to Rhode Island hospitals, 1979-80*

	Number of Persons With Diabetic Acidosis	Rate Per 10,000 Rhode Island Residents	Rate Per 10,000 Diabetics
All	137	1.4	46
Sex			
Males	49	1.1	36
Females	88	1.8	54
Age (years)			
<15	17	0.9	533
15-44	58	1.4	109
45-64	26	1.3	21
65+	36	2.8	28
Socioeconomic status			
High/middle	75	1.1	48
Low/poverty	37	1.3	28
Nursing home	13	15.5	92
Unknown	12	-	-

SOURCE: Faich, GA, HA Fishbein, and SE Ellis. The epidemiology of diabetic acidosis: A population-based study. Am J Epidemiol 117:551-58, 1983.

Incidence of DKA at onset of diabetes. In a population-based study of all hospitalizations in Rhode Island in 1979-80, DKA was found at the onset of diabetes in 20 percent of patients (Faich et al. 1983). In a study of all residents of Rochester, Minnesota, 26 percent of diabetics with onset below age 30 years presented with ketoacidosis and 15 percent of those diagnosed at age 30 years or older presented with DKA (23 percent of all diabetics) (Johnson et al. 1980). In this study, the median time interval from the diagnosis of diabetes until the patient presented with DKA was 4.6 years. This varied by age at diagnosis of diabetes, being 1.8 years in persons diagnosed below age 30 years and 9.1 years for persons diagnosed at age 30 years or older.

Hospitalization for Diabetic Acidosis

Problems in data interpretation. There are no established guidelines for classifying DKA, and various diagnostic criteria have been used, making comparison of clinical studies difficult. In addition, reliability of physician diagnosis of DKA recorded on hospital discharge files has been questioned (Faich et al. 1983, Masi 1965, Corn 1980, Demlo et al. 1978). A population-based study in Rhode Island (Faich et al. 1983), which reviewed 9,663 hospital admissions for diabetes in 1979-80, found a large proportion of misclassified cases of diabetic acidosis, using the criteria of blood glucose greater than or equal to 300 mg/dl, HCO_3 less than or equal to 15 mg/l, and pH less than 7.3. Among 152 admissions for diabetic acidosis that met the above criteria, only 117 (77 percent) were labeled on the hospital discharge record as diabetic acidosis (or ketoacidosis). Conversely, of the 174 diabetic acidosis diagnoses that were on the records, 57 (33 percent) did not meet the above criteria. Therefore, in analyses of DKA hospital discharge data, it should be borne in mind that physician labeling of diabetic acidosis may be unreliable. It would be highly desirable if case definitions for DKA were based on a defined set of biochemical values, including blood glucose, bicarbonate, and pH. If this were instituted, data sets from different clinical and population studies could be compared and provide more informative results. Despite these limitations, hospital discharge data sets are powerful sources in helping to monitor community trends of DKA and can provide starting points for more detailed investigations.

Classification of hospitalization diagnoses. The International Classification of Diseases (ICD) is used to classify causes of morbidity and mortality. In 1979, the ninth revision of this classification was instituted, which is currently used in the United States to code hospital records (NCHS 1979). If diabetes is listed on these records, the code number 250 is assigned. Three subcodes of 250 designate diabetic acidosis and/or coma in hospital records: 250.1, diabetes with ketoacidosis; 250.2, diabetes with hyperosmolar coma; and 250.3, diabetes with other coma with or without ketoacidosis. A "primary" diagnosis indicates that the condition was the major reason for the hospitalization; a "secondary" or "any" diagnosis indicates that the condition was listed on the hospital chart but was not considered to be the primary diagnosis. Before 1979, only one ICD number pertaining to DKA was in effect: 250.0, diabetes with acidosis or coma. Although acidosis and coma were combined in this code, it is likely that the majority of hospitalizations coded as 250.0 involved ketoacidosis because data since 1979 indicate that at least 85 percent of hospitalizations with acidosis and coma involve ketoacidosis.

Number of DKA hospitalizations and percent of all diabetes hospitalizations. In the United States in 1979–81, diabetic acidosis/ketoacidosis was recorded as a reason for hospitalization in 68,843 cases annually; it was the primary diagnosis in 58,678 cases and was considered a secondary diagnosis in an additional 10,165 hospitalizations (Table 2). Diabetes with coma with or without acidosis was listed in 5,768 primary diabetes hospitalizations and 1,326 secondary diabetes hospitalizations; some unknown percentage of these involved ketoacidosis. Together, these diagnoses were recorded in 10.2 percent of all diabetes primary hospitalizations and in 3.34 percent of all hospitalizations involving diabetes (Table 2). The rate of 10.2 percent is lower than that of the previous decade; in 1969–73, 14 percent of all hospitalizations where diabetes was the primary diagnosis were attributed to diabetic acidosis and coma (National Commission 1976). Although some proportion of this 14 percent was due to lactic acidosis or hyperosmolar nonketotic coma, it is likely that 10.2 percent is a distinct reduction from the rate of a decade ago.

In population-based studies in four States during 1976–80, diabetes with acidosis or coma (DAC) was considered the primary diagnosis in 6.7 percent to 13.4 percent of all diabetes primary hospitalizations (Table 3). For all hospitalizations involving diabetes, DAC was mentioned in 1.6 to 3.6 percent. Such variation is possible given the different data sources and case criteria used in identifying diabetic acidosis.

Hospitalizations for DAC by age. The proportion of hospitalizations involving DAC varies dramatically by age. Among persons ages 0–14 years in 1979–81, 33.6 percent of all diabetes primary diagnosis hospitalizations involved DAC (Table 2). This percent declined with age, such that only 4.7 percent of diabetes primary diagnosis hospitalizations in persons age 65 years and older involved DAC. Similar age trends are seen for all hospitalizations where diabetes was a diagnosis (Table 2). These percents are lower than those recorded in the previous decade. In 1969-73, 65 percent of all primary diabetic admissions among persons ages 0-19 years involved DAC. The percent declined with age: 40 percent for age 20-34 years, 12 percent for 35-49 years, 8 percent for 50-64 years, and 7 percent for 65+ years (National Commission 1976).

TABLE 2. *Average annual number of hospitalizations for diabetic acidosis and coma and percent of all diabetes hospitalizations, United States, 1979-81*

	Age (Years)				
Diagnosis (ICD Number)	All Ages	0-14	15-44	45-64	65+
Diabetes as primary hospitalization diagnosis*					
Diabetes (250)	628,300	21,300	132,300	232,600	233,000
Diabetes with ketoacidosis (250.1)	58,678	7,003	29,665	13,269	8,741
Diabetes with coma with or without ketoacidosis (250.3)	5,768	155	2,148	1,187	2,277
Sum, 250.1 and 250.3	64,446	7,158	31,813	14,456	11,018
Percent of 250*	10.2%	33.6%	24.0%	6.2%	4.7%
Diabetes as any hospitalization diagnosis					
Diabetes (250)	2,267,600	28,000	313,300	800,000	1,120,300
Diabetes with ketoacidosis (250.1)	68,843	7,344	33,039	16,455	12,005
Diabetes with coma with or without ketoacidosis (250.3)	7,094	155	2,442	1,506	2,990
Sum, 250.1 and 250.3	75,937	7,499	35,481	17,961	14,995
Percent of 250	3.34%	26.8%	11.3%	2.2%	1.3%

*The percents of all primary diabetes admissions represented by diabetes with acidosis or coma in 1969-73 were: ages 0-19, 65%; ages 20-34, 40%; ages 35-49, 12%; ages 50-64, 8%; ages 65+, 7%.

SOURCE: Hospital Discharge Surveys, National Center for Health Statistics.

TABLE 3. *Diabetic acidosis and coma (DAC; ICD 250.0) as a percent of diabetes hospitalizations, 1976-77*

	Primary Diagnosis DAC as Percent of All Diabetes Primary Diagnosis Hospitalizations			DAC as Any Listed Diagnosis as Percent of All Hospitalizations Involving Diabetes		
Location	1976	1977	1979-80	1976	1977	1979-80
Maine	13.4	11.8	-	3.3	3.6	-
Michigan (75% coverage of hospital beds)	10.7	11.4	-	-	-	-
Mississippi (PSRO data)	8.4	6.7	-	3.2	2.6	-
Rhode Island	11.5	11.7	8.8	2.9	2.5	1.6

SOURCES: Unpublished data from The Diabetes Control Program, Centers for Disease Control; and Faich, GA, HA Fishbein, and SE Ellis. Epidemiology of diabetic acidosis--A population-based study. Am J Epidemiol 117:551-58, 1983.

The age distribution of the number of DKA hospitalizations shows a different pattern. Although the largest proportion of diabetic hospital admissions due to DAC occurred among the youngest diabetics (ages 0-14 years) (Table 2), the absolute number of DAC admissions was lowest in this age group and was greatest among young adults (ages 15-44 years) (Table 4).

TABLE 4. *Age distribution of hospitalizations for diabetic acidosis and coma, United States, 1979-81*

	All Ages	Age (Years) 0-14	15-44	45-64	65+
Diabetes with acidosis (ICD 250.1) as primary hospitalization diagnosis					
Average annual number	58,678	7,003	29,665	13,269	8,741
Percent of total	100.0	11.9	50.6	22.6	14.9
Diabetes with acidosis (ICD 250.1) as any hospitalization diagnosis					
Average annual number	68,843	7,344	33,039	16,455	12,005
Percent of total	100.0	10.7	50.0	23.9	17.4
Diabetes with coma with or without ketoacidosis (ICD 250.3) as primary hospitalization diagnosis					
Average annual number	5,768	155	2,148	1,187	2,277
Percent of total	100.0	2.7	37.3	20.6	39.5
Diabetes with coma with or without ketoacidosis (ICD 250.3) as any hospitalization diagnosis					
Average annual number	7,094	155	2,442	1,506	2,990
Percent of total	100.0	2.2	34.4	21.2	42.1

SOURCE: Hospital Discharge Survey, National Center for Health Statistics.

The age pattern for diabetes with coma, with or without mention of acidosis (ICD 250.3), was somewhat different. Although a large percent of hospitalizations for diabetes with coma occurred in the young adult years (ages 15-44), a large number occurred in the elderly population (ages 65+ years) (Table 4).

Diabetes-specific DAC hospitalization rates. Table 5 shows the DAC hospitalization rates per estimated 10,000 diabetic population for two States in 1977. The rates increased with age for DAC as both the primary and the secondary cause of the hospitalization (Table 4). For all ages, DAC may have caused 131 out of every 10,000 diabetics (1.3 percent) to be hospitalized in 1977. Data from the Rhode Island study of all hospitalizations indicate that the admission rate for DKA in 1979-80 was somewhat lower (Table 1).

TABLE 5. *Number of hospitalizations for diabetic acidosis and coma (DAC) per 10,000 estimated diabetic population, Maine and Rhode Island, 1977*

Age Group (Years)	Primary Diagnosis of DAC	Secondary* Diagnosis of DAC	Total
<15	54.2	5.8	60.0
15-34	96.1	16.8	112.9
35-44	77.3	19.9	97.2
45-64	107.2	49.3	156.5
65+	179.4	120.2	299.6
All ages	96.9	33.9	130.8

*DAC (ICD 250.0) was on the hospital record but was not considered the primary reason for the hospitalization.

SOURCE: Diabetes Control Program, Centers for Disease Control.

Regional variation in DAC hospitalization. During 1969-73, there appeared to be some variation in DAC hospitalization rates in the four regions of the United States, but this may result from the differing age structures of these regions (Figure 1).

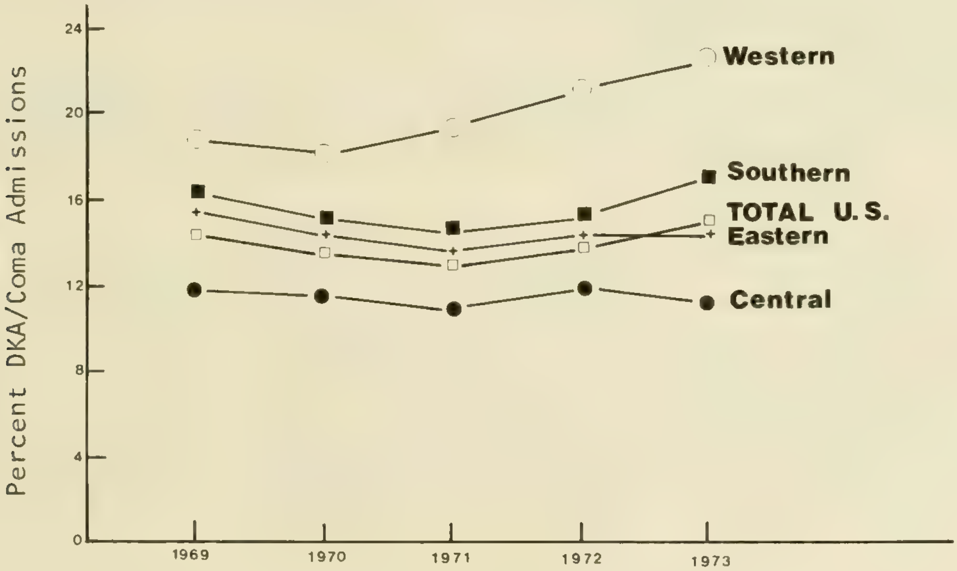

FIGURE 1. *Percent of primary diabetic hospital admissions for diabetic ketoacidosis/coma by geographic region in the United States, 1969-1973*

SOURCE: Commission of Professional and Hospital Activities (CPHA), Professional Activities Study (PAS), Ann Arbor, Michigan. In: Report of the National Commission on Diabetes, Vol. III, Part 2, p. 92.

Repeat hospitalizations for DAC. In a study of all diabetic admissions to Rhode Island hospitals in 1979-80, 15 percent (23/152) were repeat hospitalizations for DAC within the study year (Faich et al. 1983). In the population-based study of Rochester, Minnesota residents, 33 of 79 diabetics surviving a first episode of DKA had at least one subsequent episode (Johnson et al. 1980).

Causes and prevention of DAC hospitalizations. Studies on diabetic patients suggest that noncompliance and infection are the most common precipitants of DAC (Johnson et al. 1980, Cohen et al. 1960, Baker 1936, Zieve and Hill 1953, Dillon and Dyer 1937, Bortz and Spoont 1967, Beigelman 1971), although DAC frequently accompanies death from cardiovascular and renal diseases (see Tables 12 and 13 later in this chapter). Findings from two recent population-based studies indicate that noncompliance and infection may account for over 50 percent of all DAC admissions to hospitals (Faich et al. 1983, Johnson et al. 1980). Metabolic conditions that might precipitate DAC are common in diabetics, although they do not appear to be excessive in diabetics versus nondiabetics (Table 6). Emotional stress has been implicated as precipitating DKA (Hinkle and Wolf 1949, Hinkle et al. 1950, Hinkle et al. 1951a, Hinkle et al. 1951b, Hinkle and Wolf 1952) as well as relative insulin deficiency, excess of stress hormones, fasting, and dehydration (Schade and Eaton 1979). One population-based study of all Rhode Island hospitalizations in 1979-80 examined patients' behavior prior to admission for DKA and found that, during the two days prior to admission, only about 25 percent of patients telephoned or saw their physician (Table 7). Most of these patients were using insulin, and, during the two weeks before admission, about 40 percent had changed their insulin dose or frequency with or without physician advice. Another study of diabetic patients also showed that change in therapy was a frequent precipitant of DKA (Beigelman 1971).

TABLE 6. *Incidence of acute conditions that might precipitate diabetic ketoacidosis: Number of acute conditions per 100 persons per year reported by diabetics (DM)* and by all persons in the United States, 1976*

	Age (Years)							
	20+		20-44		45-64		65+	
	DM	U.S.	DM	U.S.	DM	U.S.	DM	U.S.
Infectious/parasitic diseases	18.8	16.3	28.6	20.7	15.7	11.8	18.4	10.3
Respiratory conditions	73.5	97.8	118.2	120.7	75.6	81.1	53.1	50.9
Injuries	40.4	28.7	74.6	34.4	23.6	24.2	45.7	18.8
Percent of conditions that were medically attended	63.2	54.4	65.5	51.8	64.4	58.5	60.2	63.4

*Diabetes defined as physician-diagnosed diabetes as reported by the person in a medical history interview.

SOURCE: Drury, T. National Diabetes Data Group. From unpublished data of the 1976 National Health Interview Survey, National Center for Health Statistics.

TABLE 7. *Percent distribution of reported behaviors of 58 known diabetics prior to 68 hospital admissions for diabetic acidosis, Rhode Island, April 1979-March 1980*

Behavior	Percent of Admissions
Telephoned own M.D. in the 2 days before admission	23
Telephoned any other M.D. in the 2 days before admission	3
Visited own M.D. or any M.D. in the 2 days before admission	6
Changed medication dose or frequency in the 2 weeks before admission:	
Without M.D. advice	18
With M.D. advice	22

SOURCE: Faich, GA, HA Fishbein, and SE Ellis. The epidemiology of diabetic acidosis: A population-based study. Am J Epidemiol 117:551-58, 1983.

For the known diabetic not complicated by severe cardiovascular or renal conditions, it is generally agreed that prevention of DAC is possible. DAC usually develops over a period of hours to a few days, and this slow onset allows time for medical intervention. Infrequent contact with physicians during the prodromal period suggests that there is limited access to physicians or that the patient fails to recognize symptoms of impending acidosis. Improvement in patient self-management may be needed if DKA hospital admissions are to be reduced. A few studies have shown reductions in DAC hospitalizations accompanying patient education, follow-up care, and increased access to medical advice (Miller and Goldstein 1972, Runyan 1975, National Commission 1976). In ambulatory programs having improved patient access to medical care and providing outpatient education, there has been a 40-50 percent reduction in diabetes hospitalizations among patients who have attended classes (Miller and Goldstein 1972, Runyan 1975, Goldman et al. 1983).

Economic impact of DKA hospitalizations. In a population-based study in Rhode Island, the average length of stay for DKA admission was approximately 10 days (Faich et al. 1983). The direct hospitalization cost per stay (excluding physician and laboratory fees) was approximately $3,000 (based on the estimated cost of a semi-private room in Rhode Island in 1983). There are approximately 75,000 DKA admissions in the United States each year, indicating an estimated total hospitalization cost of $225 million. The Rhode Island data suggest that 50 percent of DKA admissions result from noncompliance with diet/medication or infection, and thus half of DKA hospitalizations (38,000 admissions, $113 million) are theoretically preventable.

DKA Mortality

Problems in data interpretation. In regard to mortality data, the same problems with documentation of DKA may exist that occur with hospitalization data. In addition, underreporting of diabetes in United States vital statistics is well known. For example, in 1978, although 2,848 deaths were attributed to diabetes with acidosis and coma as the underlying cause of death, this condition was listed as a contributing factor in an additional 2,366 deaths (Harris 1978). These latter deaths are not counted in vital statistics reporting systems; hence mortality from DKA is undernumerated by national or state mortality statistics.

Number of DKA deaths. Diabetic ketoacidosis (ICD 250.1) was considered the underlying cause of death in 1,772 deaths in the United States in 1980 (Table 8). Diabetic coma, with or without acidosis and with or without hyperosmolar coma (ICD 250.2), was considered the underlying cause in 1,240 deaths; this category includes some unknown number of DKA deaths. Although DKA was a minor cause of death in the oldest age group, accounting for only 3.8 percent of deaths occurring over age 65 years, 53 percent of all DKA deaths occurred in that age group. While DKA caused only 74 deaths at ages less than 25 years, it accounted for 41 percent of diabetes deaths in this age group.

TABLE 8. *Number of deaths attributed to diabetic acidosis and coma as the underlying cause of death, and percent of all diabetes underlying cause of deaths, United States, 1980*

	Age (Years)						
Cause of Death and ICD Number	All	0-24	25-44	45-64	65-74	75-84	85+
Diabetes with ketoacidosis (acidosis and/or ketosis), 250.1							
Percent of all diabetes deaths	5.1%	40.9%	16.8%	6.3%	3.9%	3.9%	3.3%
All deaths	1,772	74	247	506	392	391	162
Males	779	41	138	239	167	144	50
Females	993	33	109	267	225	247	112
Whites	1,315	54	170	337	302	311	141
Blacks	431	19	72	159	85	75	21
Diabetes with coma (w/wo ketoacidosis, w/wo hyperosmolar coma), 250.2							
Percent of all diabetes deaths	3.6%	16.6%	5.6%	3.4%	2.9%	3.4%	4.3%
All deaths	1,240	30	82	268	296	348	215
Males	497	14	46	134	117	125	61
Females	743	16	36	134	179	223	154
Whites	924	25	52	175	214	274	184
Blacks	306	5	30	88	81	71	30

SOURCE: Death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

DKA as percent of all diabetes mortality. In 1980, 250.1 and 250.2 together represented 8.6 percent of all deaths where diabetes was selected as the underlying cause of death (Table 8). Before 1979, the ICD did not differentiate between ketoacidosis and other causes of acidosis and coma. Deaths coded as 250.0, "diabetes with mention of acidosis or coma," thus included not only DKA but also all other causes of coma and acidosis. Between 1970 and 1978, diabetes with acidosis or coma accounted for 10 percent of all deaths attributed to diabetes as the underlying cause of death in the United States (Table 9). The percent varied from 8.4 to 10.6 percent during this 9-year period (Holman et al. 1983). In 1978, DAC was also present on 2.5 percent of death certificates where diabetes was considered a contributing cause of death (Table 9).

Mortality rate among diabetics with DAC. In a 1979-80 study of all diabetic admissions to Rhode Island hospitals, 152 episodes of DAC occurred in 137 persons; mortality was 9 percent (Faich et al. 1983). In a population-based study in Rochester, Minnesota, 92 diabetics among 1,536 identified during 1945-70 experienced DKA. Thirteen deaths (14 percent) occurred within 48 hours after admission for DKA. Of 79 survivors of the initial episode, 11 percent died during a subsequent episode of DKA (Johnson et al 1980).

TABLE 9. *Diabetes with acidosis or coma as percent of all diabetes deaths annually, United States, 1970-80*

Reference	Cause of Death and ICD Numbers	Primary Cause of Death		Contributing Cause of Death	
		Number	Percent	Number	Percent
a	1980				
	Diabetes, 250	34,851	100.0	-	-
	Diabetes with keto-acidosis, 250.1	1,772	4.7	-	-
	Diabetes with coma, w/wo acidosis, 250.3	1,240	3.6	-	-
b	1978				
	Diabetes, 250	33,841	100.0	94,481	100.0
	Diabetes with acidosis or coma, 250.0	2,848	8.4	2,366	2.5
c	1970-78				
	Diabetes, 250	328,000	100.0	-	-
	Diabetes with acidosis or coma, 250.0	32,630	10.0	-	-

TABLE REFERENCES

a. Division of Vital Statistics, National Center for Health Statistics.

b. Harris, MI. National Diabetes Data Group. Unpublished analyses of the 1978 United States death certificates.

c. Holman, RC, CA Herron, and P Sinnock. Epidemiologic characteristics of mortality from diabetes. Am J Public Health 73:1169-73, 1983.

Survival from DKA seems to have improved greatly over the last 50 years. Summary of 26 clinical studies in the literature shows that, between 1923 and 1968, mortality for patients admitted in DKA varied from 0 to 44 percent (Appendix A). Analysis of 3,307 patients described in the literature revealed that mortality among patients with DKA since 1960 is considerably lower than that observed during 1930-59 (Table 10).

TABLE 10. *Mortality rate and major causes of death in 3,007 patients treated for diabetic ketoacidosis*

Time Period	Number of DKA Cases	Total Mortality (Percent)	Percent of Deaths Due To:		
			Infection	Arterial Thrombosis	Shock
1930-1959	1,538	38	41	25	28
1960-1975	1,769	9	25	33	38

SOURCE: Clements, RS, Jr, and B Vourganti. Fatal diabetic ketoacidosis: Major causes and approaches to their prevention. Diabetes Care 1:314-25, 1978.

Figure 2 presents the average mortality rate for DAC as the underlying cause of death per 100,000 estimated diabetics in the United States in 1970-78. A U-shaped curve is seen; rates were highest in the age groups 65 years and older, intermediate for deaths occurring under age 15, and lowest at ages 45-64 years. The average mortality over the 9-year period was 57 per 100,000 diabetics per year. Rates per 100,000 diabetics for nonwhites were twice those of whites (107 versus 50 per 100,000). Female rates per 100,000 diabetics were higher than male rates (73 versus 58 per 100,000) (Holman et al. 1983). Annual rates decreased significantly, from 74 to 36 per 100,000 diabetics, over the study period.

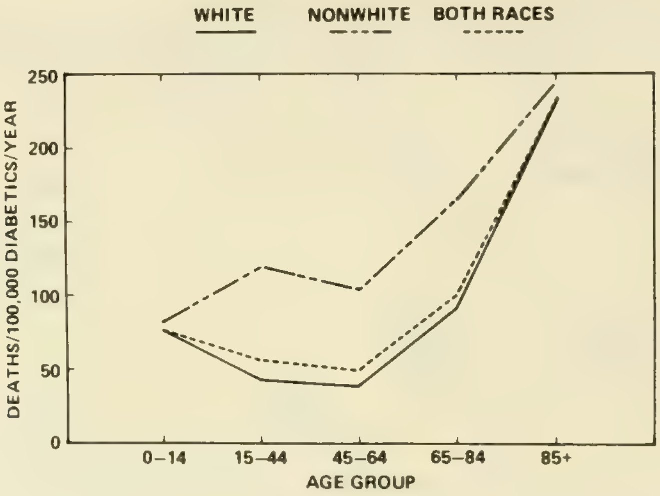

FIGURE 2. *Average diabetic ketoacidosis (DKA) mortality rates by age and race for the diabetic population, United States, 1970-78*

SOURCE: Holman, RC, CA Herron, and P Sinnock. Epidemiologic characteristics of mortality from diabetes with acidosis or coma. Am J Public Health 73:1169-73, 1983.

Mortality per 100,000 United States population by race and sex. Among deaths where DAC was the underlying cause in 1970-78, the rate of death was 1.3 per 100,000 persons per year (Table 11). The rate for nonwhites was 3.1 times that of whites. The rate for females was 1.3 times that of males.

TABLE 11. *Age-adjusted average annual mortality rates from diabetic acidosis and coma, United States, 1970-78*

Region	Number of Deaths Per 100,000 Persons Per Year			
	All Persons	White	Nonwhite	Nonwhite/White Ratio
Northeast	1.3	1.1	3.1	3.1
North Central	1.3	1.1	3.3	3.3
South	1.4	1.0	3.9	3.9
West	1.0	1.0	2.0	2.0
Total U.S.	1.3	1.1	3.4	3.1

SOURCE: Holman, RC, CA Herron, and P Sinnock. Epidemiologic characteristics of mortality from diabetes with acidosis or coma. Am J Public Health 73:1169-73, 1983.

Mortality by region. In 1970-78, the average age-adjusted rate of DAC as the underlying cause of death varied by state from 0.7 to 1.9 per 100,000 population per year, being generally lower in the western and higher in the southern part of the United States (Holman et al. 1983). Differences by region were small, but the rate in the west was lower than the rate in other regions (Table 11).

Causes of death among diabetics with DAC. No other conditions were listed in 431 of the 2,848 (15 percent) death certificates filed in the United States in 1978 in which DAC was the underlying cause of death (Table 12). Symptoms and ill-defined conditions were listed on 26 percent, indicating that deaths from DAC may not be well-investigated. Circulatory system diseases appeared to play a major role in DAC deaths, being present on 79 percent of certificates. Respiratory and kidney diseases were both present on 15 percent of certificates. Table 13 shows that DAC was recorded as a contributing cause of death in 2,366 death certificates mentioning diabetes in 1978. For all ages, about half of these were due to ischemic heart disease and cerebrovascular disease; the percent due to these conditions increased with increasing age at death.

HYPEROSMOLAR NONKETOTIC COMA

Introduction

Hyperglycemia with subsequent dehydration and stupor without ketoacidosis are the hallmark symptoms of hyperosmolar nonketotic coma (HNC). This condition generally develops over a period of several days or weeks. Because of the long development period of HNC, great potential exists for recognizing and preventing this condition.

TABLE 12. *Contributing causes of death recorded on death certificates where diabetes with acidosis or coma was selected as the underlying cause of death, United States, 1978*

		Age (Years)							
		All Ages		0-34		35-64		65+	
Contributing Cause of Death	ICD Number	N	%	N	%	N	%	N	%
All causes	-	2,848	100.0	246	100.0	932	100.0	1,669	100.0
No other listed condition	-	431	15.1	79	32.1	155	16.6	197	11.8
Infectious and parasitic diseases	000-136	243	8.5	19	7.7	94	10.1	130	7.9
Neoplasms (benign and malignant)	140-239	147	5.2	1	0.4	44	4.7	101	6.1
Endocrine, nutritional, metabolic diseases	240-279	130	4.6	9	3.6	58	6.2	63	3.8
Blood diseases	280-289	46	1.6	1	0.4	23	2.5	22	1.3
Mental system diseases	290-315	147	5.2	11	4.5	60	6.4	76	4.6
Nervous system diseases	320-389	143	5.0	14	5.7	48	5.2	81	4.9
Circulatory system diseases	390-458	2,249	79.0	82	33.3	590	63.3	1,573	94.2
Hypertensive disease	400-404	99	3.5	2	0.8	34	3.6	61	3.7
Ischemic heart disease	410-414	635	22.2	9	3.7	153	16.4	472	28.3
Other forms of heart disease	420-429	761	26.7	53	21.5	228	24.5	479	28.7
Cerebrovascular disease	430-438	428	15.0	11	4.5	95	10.2	320	19.2
Diseases of arteries	440-458	318	11.2	7	2.8	67	7.2	234	14.0
Respiratory system diseases	460-519	440	15.4	33	13.4	153	16.4	254	15.2
Digestive system diseases	520-577	287	10.1	20	8.1	146	15.7	121	7.3
Kidney/urinary system diseases	580-629	432	15.2	18	7.3	154	16.5	260	15.6
Symptoms/ill-defined conditions	780-796	7,371	25.9	62	25.2	229	24.6	446	26.7
All other	-	200	7.0	21	8.5	71	7.6	76	4.6

SOURCE: Harris, MI. National Diabetes Data Group. Unpublished analyses of the 1978 United States death certificates.

TABLE 13. *Diabetes with acidosis or coma (ICD 250.0) recorded as a contributing cause of death on death certificates, United States, 1978*

		Age (Years)							
		All Ages		0-34		35-64		65+	
Underlying Cause of Death	ICD Number	N	%	N	%	N	%	N	%
All causes	-	2,366	100.0	66	100.0	590	100.0	1,709	100.0
Infectious and parasitic diseases	000-136	120	5.1	6	9.0	40	6.8	74	4.3
Neoplasms (benign and malignant)	140-239	222	9.4	1	1.5	58	9.8	162	9.5
Endocrine, nutritional, metabolic diseases	240-279	62	2.6	3	4.5	19	3.2	40	2.3
Blood diseases	280-289	8	0.3	1	1.5	3	0.5	4	0.2
Mental system diseases	290-315	28	1.2	1	1.5	11	1.9	16	0.9
Nervous system diseases	320-389	46	1.9	5	7.8	18	3.1	23	1.4
Circulatory system diseases	390-458	1,275	53.9	12	18.1	260	44.1	1,003	58.7
Hypertensive disease	400-404	58	2.4	0	0	11	1.9	46	2.7
Ischemic heart disease	410-414	580	24.5	2	3.0	120	20.3	458	26.8
Other forms of heart disease	420-429	125	5.3	3	4.5	48	8.1	74	4.3
Cerebrovascular disease	430-438	413	17.5	3	4.5	53	9.0	357	20.9
Diseases of arteries, arterioles, capillaries	440-458	87	3.7	0	0	24	4.1	63	3.7
Respiratory system diseases	460-519	220	9.3	13	19.7	52	8.8	155	9.1
Digestive system diseases	520-577	158	6.7	10	15.2	66	11.2	82	4.8
Kidney/urinary tract diseases	580-629	164	6.9	3	4.5	40	6.8	121	7.1
All other	630-799, E codes	65	2.7	6	9.1	19	3.2	18	1.1

SOURCE: Harris, MI. National Diabetes Data Group. Unpublished analyses of the 1978 United States death certificates.

Morbidity and Mortality

United States hospital discharge data for 1979-81 show that most episodes of HNC occur in older diabetics (Table 14). Several patient studies provide similar results (Sament and Schwartz 1957, Schwartz and Apfelbaum 1966, Assan et al. 1969, Gerich et al. 1970, Keller et al. 1975). These data suggest that HNC causes coma one-sixth as often as DKA. Occurrences of HNC in children and in insulin-dependent diabetics are generally infrequent (Kolodny and Sherman 1968). Among diabetics hospitalized with HNC, approximately 40-50 percent die in the hospital (Schwartz and Apfelbaum 1966, Keller et al. 1975, McCurdy 1970, Dibenedetto et al. 1965, Arieff and Carroll 1972), although one study found only 10 percent mortality (Matz 1974). Because HNC has always been subsumed under the mortality code for "diabetes with coma," it is impossible to ascertain from national or state death data the extent of mortality associated with HNC.

TABLE 14. *Average annual number of hospitalizations for hyperosmolar nonketotic coma (HNC, ICD 250.2), United States, 1979-81*

	Age (Years)				
	All Ages	0-14	15-44	45-64	65+
Primary diagnosis of HNC	3,415	0	414	978	2,022
All diagnoses of HNC	5,194	30	495	1,382	3,288

SOURCE: United States Hospital Discharge Survey, National Center for Health Statistics.

Causes and Prevention of HNC

HNC episodes have been reported to be due to steroid (Boyer 1967) and thiazide diuretic therapy (McCurdy 1970). Other isolated findings show that pneumonia, pancreatitis, stroke, renal dialysis, burns, and heat stroke may all precipitate HNC (Dibenedetto 1965, Cohen et al. 1968, Maccario et al. 1965, Potter 1966, Rosenberg et al. 1965, Montclione and Keefe 1969).

This syndrome occurs most often among elderly diabetic patients. Since the prevalence of diabetes increases with age, there is potentially a large group of patients who are at risk of HNC. HNC is also reported as occurring frequently in patients who have cerebrovascular disease, which may prevent the patient from recognizing the symptoms of HNC and seeking medical treatment (Rifkin and Raskin 1981). In addition, the elderly diabetic with vascular complications is likely to be on diuretic therapy, which, by causing dehydration, may further increase the risk of HNC.

LACTIC ACIDOSIS

The hallmark of lactic acidosis (LA) is the persistence of acidosis as ketonemia clears. The result is an accumulation of lactic acid in the body rather than ketoacids as in ketoacidosis (Tranquada et al. 1966). As with ketoacidosis, there is no agreed-upon definition of LA.

Few data exist on the occurrence of LA or subsequent patient outcomes. Incidence of LA for patients on the antidiabetic biguanide phenformin was estimated at 5-14 cases per 1,000 patient-years of treatment (Cohen 1979). LA mortality is reported at 50 percent for patients on phenformin therapy (Luft et al. 1978). High LA mortality induced by phenformin has been reported from other reviews (Dembo et al. 1975, Cohen and Woods 1976). Because of these results, there has been a marked decline in phenformin use, and it is no longer marketed in the United States.

HYPOGLYCEMIA

Hypoglycemia implies a low level of blood glucose, but standards for diagnosing this condition have not been established. Several studies have reported hypoglycemia among randomly selected diabetics (Malins 1968, Paz-Guevara et al. 1975, Goldgewicht et al. 1983), but these represent only crude estimates of prevalence. Among 3,702 persons tested for fasting plasma glucose in a national probability survey, only 0.3 percent had fasting plasma glucose values less than 60 mg/dl (Harris 1983). Table 15 presents the United States hospitalization data on hypoglycemia, but these should be viewed with great caution because of the lack of diagnostic criteria for hypoglycemia.

No data exist that fully support the notion that "reactive" hypoglycemia promotes onset of diabetes mellitus.

TABLE 15. *Hospital discharges with hypoglycemia (ICD 251.0) as the primary discharge diagnosis, United States, 1979-81*

	1979	1980	1981
Number of discharges	10,107	8,337	8,509
Number of days of hospitalization	76,619	53,054	49,191
Average number of days per hospitalization	7.6	6.4	5.8

SOURCE: Sinnock, P. Centers for Disease Control. Unpublished data of the Hospital Discharge Survey, National Center for Health Statistics.

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APPENDIX A. *Number of hospitalizations for diabetic acidosis and coma*, and annual incidence (number per 1,000 diabetics), United States, 1980*

Age (Years)	Male		Female		Both Sexes	
	Number	Incidence	Number	Incidence	Number	Incidence
<15	2,411	58.8	4,693	134.1	7,104	93.5
15-44	14,476	37.1	21,653	45.8	36,129	41.9
45-64	5,644	5.7	9,640	7.4	15,284	6.7
65+	5,496	8.5	10,948	9.2	16,444	9.0
Total	28,027	13.6	46,934	15.6	74,961	14.8

*ICDA9: 250.1 and 250.3, any of seven diagnoses, mentioned on the hospital record.

SOURCE: DHHS Task Force on Minority Health, Diabetes Subcommittee, 1983, from the 1980 Hospital Discharge Survey and the 1980 Health Interview Survey, National Center for Health Statistics.

APPENDIX B. *Diabetic ketoacidosis* mortality: Summary of the literature*

City	Years	Number of DKA Episodes	Deaths	
			Number	Percent
Boston	1923-66	1,216	87	7
Boston	1946-66	-	-	4.6
Rochester, Minn.	1923-34	74	11	15
Buffalo	1923-29	81	10	12
Cincinnati	1923-37	60	25	42
Los Angeles	1930-40	315	105	33
Minneapolis	1930-48	84	23	27
Philadelphia	1931-36	165	73	44
Philadelphia	1941	107	29	27
New York	1940-51	100	13	13
New York	1952-57	60	1	2
Seattle	1942-49	32	3	9
Seattle	1948-52	53	0	0
Boston	1944-50	67	1	1
Cincinnati	1947-51	140	44	31
Cincinnati	1952-56	172	25	15
London, England	1948-63	61	5	8
Sydney, Australia	1950-55	69	11	16
Boston	1952-55	42	2	5
Melbourne, Australia	1952-55	67	21	31
Melbourne, Australia	1956-67	32	1	3
Baltimore	1958-59	30	2	7
Paris, France	1959-62	133	16	12
Paris, France	1963-67	154	23	15
Philadelphia	1960-64	149	21	14
San Francisco	1964-68	25	0	0
Los Angeles	1965-68	340	32	9

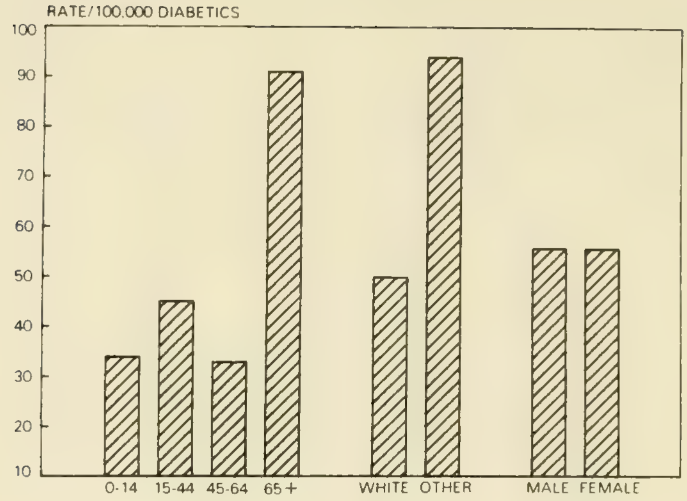
*Based on bicarbonate levels of approximately 10 mEq/l or less.

SOURCE: Beigleman, PM. Severe diabetic ketoacidosis. Diabetes 20:490-97, 1971.

APPENDIX C. *Summary of data from clinical centers regarding incidence and mortality from diabetic ketoacidosis, hyperosmolar coma, and lactic acidosis*

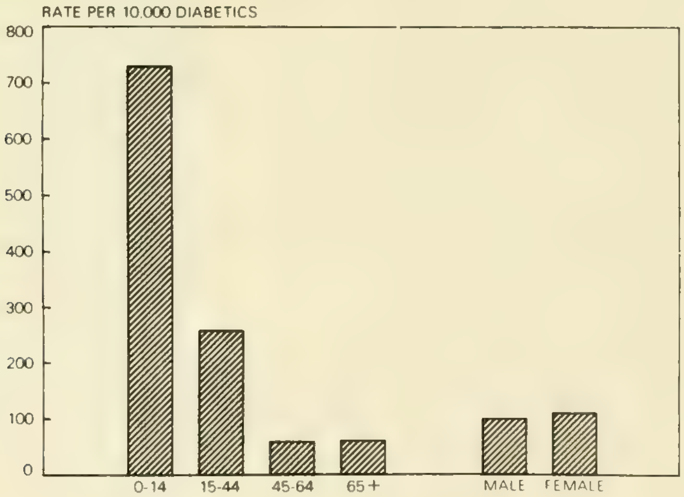
		Ketoacidosis or Coma			Hyperosmolar Coma			Lactic Acidosis		
Hospital	Period	Total Admissions	Deaths	Percent Mortality	Total Admissions	Deaths	Percent Mortality	Total Admissions	Deaths	Percent Mortality
N.E. Deaconess, Boston	7/73-12/74	134	1	0.74	11	1	9.10	3	1	33.3
Peter Bent Brigham, Boston	1/72-6/75	48	5	10.40						
St. Elizabeth, Boston	7/71-7/75	37	5	13.50						
Boston City, Boston	4/71-7/75	309	24	7.76						
Mayo Clinic, Rochester, Minn.	1965-1972	149	23	15.44						
Medical College, Richmond, Va.	1974	40	1	2.50	12	1	8.33	60	19	31.67
St. Mary's, St. Louis, Mo.	1965-1974	227	12	5.30						
St. John's Mercy, St. Louis, Mo.	1969-1973	154	5	3.25						
Evanston, Chicago	1970-1974	203	-	-						
Northwestern Memorial, Chicago	1969-1974	191	-	-						
Henry Ford, Detroit	1970-1974	361	2	0.55						
Univ. of Colorado, Denver	7/73-6/74	45	1	2.22				26	5	19.23
Long Beach V.A., L.A.	1970-1974	247	46	18.62						
USC Med. Ctr., L.A.	1970-1974	459	28	6.10	149	35	23.42			
Mt. Sinai, N.Y.	1970-1974	138	6	4.35						

SOURCE: National Commission on Diabetes. Report to the Congress of the United States. Vol. III, Part 2. USDHEW Pub. No. (NIH) 76-1022. Washington, DC: Supt. of Docs., U.S. Govt. Print. Off., 1975. p. 95.



APPENDIX D. *1978 United States deaths due to DKA by age, race, and sex*

SOURCE: Sinnock, P, RC Holman, R Most, and S Teutsch. Assessment of diabetes morbidity/mortality data in Diabetes Control Program states. 5th Diabetes Control Conference, Lexington, KY, May 1982.



APPENDIX E. *Estimated 1978 United States rates of hospitalization with a primary diagnosis of DKA*

SOURCE: Sinnock, P, RC Holman, R Most, and S Teutsch. Assessment of diabetes morbidity/mortality data in Diabetes Control Program states. 5th Diabetes Control Conference, Lexington, KY, May 1982.

CHAPTER XIII. VISION DISORDERS IN DIABETES

Ronald Klein, M.D., M.P.H., and Barbara E.K. Klein, M.D., M.P.H.

SUMMARY

Diabetes, particularly diabetic retinopathy, is the leading cause of new cases of blindness in people ages 20 to 74 years in the United States. Approximately 8 percent of those who are legally blind are reported to have diabetes as the etiology, and it is estimated that more than 12 percent of new cases of blindness are attributable to diabetes. Twelve percent of insulin-dependent persons with diabetes for 30 or more years are blind. Persons who have diabetic retinopathy are 29 times more likely to be blind than nondiabetic persons. Blindness due to diabetes is estimated to involve lost income and public welfare expense of $75,000,000 annually.

Four complications of diabetes that may lead to blindness are retinopathy, cataracts, glaucoma, and corneal disease. Diabetic retinopathy is characterized by alterations in the small blood vessels in the retina. An estimated 97 percent of insulin-taking and 80 percent of noninsulin-taking persons with diabetes for 15 or more years have retinopathy; approximately 40 percent of insulin-taking and 5 percent of noninsulin-taking persons have the most severe stage, proliferative diabetic retinopathy. Recent studies have shown the efficacy of panretinal photocoagulation in reducing the incidence of serious loss of vision (worse than 5/200) in persons with severe proliferative retinopathy by about 50 percent. Regular ophthalmologic consultation and examination are indicated in the care of these patients because timely panretinal photocoagulation treatment may prevent visual loss. This is especially important for diabetic individuals, who may be unaware of the potential for loss of vision because diabetic retinopathy is usually associated with good vision in its early stages. Even patients with new blood vessel growth may be unaware of the threat to vision until a serious hemorrhage into the vitreous body occurs.

Other causes of visual loss that occur more frequently in patients with diabetes compared to nondiabetic persons are cataract (clouding of the lens), glaucoma (damage to the optic nerve, with subsequent loss of visual field due to relatively increased intraocular pressure), and corneal disease.

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At present, early age at onset and longer duration of diabetes are the only well-recognized risk factors for development of visual impairment and blindness in diabetic persons. There is a need for population-based incidence data to define other factors that convey increased risk for vision loss and to provide estimates of the relative importance of these factors in developing visual impairment from diabetic retinopathy, glaucoma, cataract, and corneal disease. Accurate data concerning the needs of the visually impaired for occupational, vocational, psychosocial, and medical services are necessary to describe the current situation and to plan for future health care delivery. In addition, preventive trials for intervention on alterable risk factors are necessary to determine whether medical therapy can prevent disease progression and vision loss.

VISUAL IMPAIRMENT AND BLINDNESS

Definitions

The following classifications of visual impairment have been widely used. They are described in terms of a Snellen fraction* (Council on Clinical Classifications 1978):

- no impairment—better than 20/40 in the better eye
- minimal impairment—from 20/40 to 20/60
- moderate impairment—20/70 to 20/160
- severe impairment (legal blindness)—20/200 or worse

Prevalence

Estimates of legal blindness in the United States for 1978 have been reported by the National Society to Prevent Blindness (1980) from data of the Model Reporting Area (MRA) registry, which had been collected in December 1970 (Kahn and Moorhead 1973, USDHEW 1963). They estimated that 7.9 percent of people who were legally blind reported diabetes as the cause of their blindness (Table 1).

Prevalence rates for diabetes-related causes of legal blindness increased with increasing age to a maximum in persons 65 to 74 years of age; thereafter, the rates declined. This decline may be due to excess deaths in the elderly diabetic population, in which the disease had already progressed to the stage of blindness. The relative proportion of cases attributed to diabetic retinopathy declined with increasing age. Rates for females were higher than for males. Higher rates of legal blindness were found in white females and in nonwhite males and females, compared to white males (Table 2). Since the MRA registry data were based on self-reports and required registration at specific agencies in 16 states, the rates are thought to underestimate the actual prevalence of legal blindness by as much as 50 percent (Kahn and Hiller 1974).

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*If a patient can identify a line of letters that subtends an angle of 5 minutes at 20 feet, his vision is expressed as 20/20. The numerator of the fraction denotes the distance at which the test is conducted and the denominator the distance at which the letter subtends an angle of 5 minutes.

TABLE 1. *Prevalence of legal blindness due to diabetes and diabetic retinopathy, by age and sex, United States, 1978*

Age and Sex	Number of Cases of Legal Blindness Due to Diabetes	Percent of Total Cases of Legal Blindness Due to Diabetes	Number of Cases of Legal Blindness Due to Diabetic Retinopathy	Percent of Total Cases of Legal Blindness Due to Diabetic Retinopathy
Age (years)				
<5	0	0	0	0
5-19	<50	<0.1	<50	<0.1
20-44	4,000	4.8	3,500	4.2
45-64	12,250	11.3	10,600	9.8
65-74	13,700	14.4	11,150	11.7
75-84	7,850	7.5	6,200	6.0
85+	1,700	2.6	1,200	1.8
Sex				
Males	14,750	6.1	12,800	5.3
Females	24,750	9.7	19,850	7.7
Total	39,500	7.9	32,650	6.6

SOURCE: National Society to Prevent Blindness. Vision Problems in the United States, 1978. Estimated from 1970 Model Reporting Area Data.

TABLE 2. *Age-adjusted relative risk of blindness due to diabetes by race and sex, Model Reporting Area Registry, 1978**

Race and Sex	Relative Risk Compared to Diabetic White Males
White males	1.00
White females	1.25
Nonwhite males	1.27
Nonwhite females	3.83

*Age-adjusted by direct method to total 1970 census population of 14 participating Model Reporting Area states.

SOURCE: Kahn, HA, and R Hiller. Blindness caused by diabetic retinopathy. Am J Ophthalmol 78:58, 1974.

Blindness from all causes in the United States is shown in Table 3 for comparison to blindness attributable to diabetes.

Another source of information concerning the rate of visual impairment in persons with diabetes is the 1976 National Health Interview Survey (NHIS) (Howie and Drury 1978). These survey data were obtained by questioning a sample of approximately 120,000 persons in the United States. Visual impairment was determined by the self-reported "inability to read a newspaper," and the presence and duration of diabetes was determined by self-reported physician's diagnosis of diabetes and the year of the diagnosis. The prevalence of visual impairment in both the diabetic and the nondiabetic populations was found to increase with increasing age (Figure 1). There appeared to be a trend within each age group of increased prevalence of impairment with longer duration of diabetes (Groups 4, 5, 6). Twenty-five percent of persons 65

TABLE 3. *Leading causes of legal blindness, by age and sex, United States, 1978*

Age, Sex, and Cause	Number	Percent	Rate*
TOTAL			
1. Glaucoma, except congenital	62,100	12.5	28.1
2. Macular degeneration	58,250	11.7	26.3
3. Senile cataract	41,500	8.3	18.7
4. Optic nerve atrophy	34,500	7.0	15.6
5. Diabetic retinopathy	32,650	6.6	4.8
6. Retinitis pigmentosa	23,250	4.7	10.5
7. Myopia	19,850	4.0	8.9
All other	225,900	45.2	102.1
Total	498,000	100.0	225.1
Under 5 years of age			
1. Prenatal cataract	1,050	16.3	6.8
2. Optic nerve atrophy	800	12.4	5.2
3. Retrolental fibroplasia	600	9.3	3.9
4. Anophthalmos, microphthalmos	400	6.2	2.6
Glaucoma, congenital	400	6.2	2.6
5. Retinoblastoma	250	3.9	1.6
All other	2,700	45.7	17.6
Total in age group	6,450	100.0	42.0
5-19 years of age			
1. Prenatal cataract	4,500	12.9	8.0
2. Optic nerve atrophy	4,250	12.2	7.5
3. Retrolental fibroplasia	2,950	8.5	5.2
4. Albinism	2,500	7.1	4.4
5. Myopia	2,250	6.5	4.0
6. Nystagmus	1,900	5.5	3.4
All other	16,400	47.3	29.0
Total in age group	34,750	100.0	61.6
20-44 Years of age			
1. Retrolental fibroplasia	8,950	10.8	11.4
2. Optic nerve atrophy	8,550	10.3	10.9
3. Retinitis pigmentosa	6,200	7.5	7.9
4. Prenatal cataract	4,450	5.4	5.7
5. Myopia	4,050	4.9	5.2
6. Macular degeneration	3,650	4.4	4.7
7. Diabetic retinopathy	3,500	4.2	4.5
All other	43,450	52.5	55.5
Total in age group	82,800	100.0	105.7
45-64 Years of age			
1. Glaucoma, except congenital	12,150	11.2	27.7
2. Diabetic retinopathy	10,600	9.8	24.2
3. Retinitis pigmentosa	9,550	8.8	21.8
4. Optic nerve atrophy	9,300	8.6	21.2
5. Senile cataract	5,850	5.4	13.3
6. Macular degeneration	5,400	5.0	12.3
7. Myopia	5,300	4.9	12.1
All other	49,900	36.3	113.8
Total in age group	108,050	100.0	246.4
65-74 years of age			
1. Glaucoma, except congenital	17,250	18.1	115.5
2. Diabetic retinopathy	11,150	11.7	74.7
3. Senile cataract	8,600	9.0	57.6
4. Macular degeneration	8,300	8.7	55.6
5. Optic nerve atrophy	6,200	6.5	41.5
6. Retinitis pigmentosa	4,200	4.4	28.1
7. Myopia	4,150	4.4	27.8
All other	35,250	37.2	236.0
Total in age group	95,100	100.0	636.8
75-84 years of age			
1. Macular degeneration	21,800	20.8	315.3
2. Glaucoma, except congenital	20,050	19.2	290.0
3. Senile cataract	12,950	12.4	187.3
4. Diabetic retinopathy	6,200	6.0	89.7
5. Optic nerve atrophy	3,900	3.8	56.4
All other	39,700	37.8	574.2
Total in age group	104,600	100.0	1,512.9
85 Years of age and over			
1. Macular degeneration	17,900	27.8	811.4
2. Senile cataract	13,650	20.6	618.8
3. Glaucoma, except congenital	10,850	16.4	491.8
All other	22,050	35.2	999.5
Total in age group	66,250	100.0	3,003.2
65 Years of age and over			
1. Glaucoma, except congenital	48,150	18.1	200.2
2. Macular degeneration	48,000	18.0	199.6
3. Senile cataract	35,200	13.2	146.3
4. Diabetic retinopathy	18,500	7.0	76.9
5. Optic nerve atrophy	11,600	4.4	48.2
All other	104,500	39.3	434.4
Total in age group	265,950	100.0	1,105.6
Males			
1. Glaucoma, except congenital	27,600	11.4	26.0
2. Macular degeneration	21,900	9.1	20.6
3. Optic nerve atrophy	21,500	8.9	20.3
4. Retinitis pigmentosa	15,000	6.2	14.1
5. Senile cataract	14,500	6.0	13.7
All other	141,050	58.4	133.0
Total males	241,550	100.0	227.8
Females			
1. Macular degeneration	36,350	14.2	32.5
2. Glaucoma, except congenital	34,500	13.5	30.8
3. Senile cataract	27,000	10.5	24.1
4. Diabetic retinopathy	19,850	7.7	17.7
5. Optic nerve atrophy	13,000	5.1	11.6
All other	125,750	49.0	112.3
Total females	256,450	100.0	228.9

*Number per 100,000 population in each age group and sex. The rates are based on the following population estimates (in thousands) as of July 1, 1978 (Ferris et al. 1982): Under 5 years, 15,361; 5-19 years, 56,458; 20-44 years, 78,340; 45-64 years, 43,845; 65-74 years, 14,934; 75-84 years, 6,914; 85 years and over, 2,206; males, 106,043; females, 112,016.

SOURCE: National Society to Prevent Blindness. Vision Problems in the United States, 1978. Estimated from 1970 Model Reporting Area data.

years of age or older who had diabetes for 15 or more years reported visual impairment. These data may also underestimate visual impairment, since the sensitivity of responses to questions about vision is low (approximately 32 to 45 percent) (Hiller and Krueger 1983).

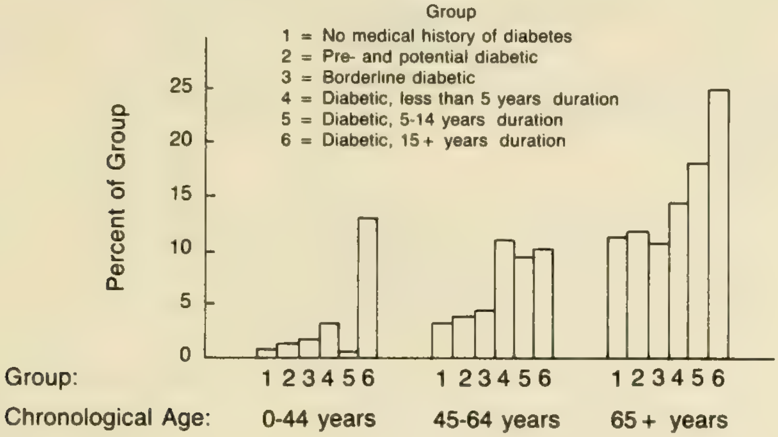

FIGURE 1. *The relationship between reported prevalence of "inability to read the newpaper" in nondiabetic and diabetic populations by chronologic age and duration of diabetes*

SOURCE: Harris, MI, National Diabetes Data Group. Unpublished data from the 1976 Health Interview Survey, National Center for Health Statistics.

Population-based estimates of visual impairment in diabetic persons were reported in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) (R Klein et al. 1984a), in which a standardized protocol for determination of visual acuity was used (ETDRS 1980, Ferris et al. 1982). The objectives of the study were to describe the prevalence and severity of diabetic retinopathy, visual impairment, and other ocular and systemic conditions. The associations of these conditions with other personal and demographic characteristics in a geographically defined population in an 11-county area in southern Wisconsin were examined. The participants and their diabetic management were typical of current medical practice in Wisconsin. Four hundred fifty-two physicians (98.9 percent of all physicians who offered primary care to diabetic patients in the 11-county area) participated (R Klein et al. 1984b). Of the 10,135 diabetic patients identified in this survey, all insulin-taking persons diagnosed prior to 30 years of age (1,210 persons, the "younger-onset" group) and a probability sample of patients diagnosed as having diabetes at or after 30 years of age (1,780 persons, the "older-onset" group) were invited to participate in the examination phase of the study, conducted from September 1980 to July 1982. The participation rate was 79 percent. Ninety-two percent of the younger-onset group had no visual impairment (best corrected visual acuity in the better eye of better than 20/40). Visual impairment was found to increase with increasing age (Figure 2). No cases of legal blindness were found in persons younger than 25 years of age. The rate of legal blindness increased in both males and females, reaching peaks of 14 percent and 20 percent respectively. In the older-onset group, rates of blindness increased with increasing age and accounted for 2.2 percent in persons not taking insulin and 1.6 percent in those taking insulin (Figure 3). The age-specific rates of legal blindness in both younger- and older-onset

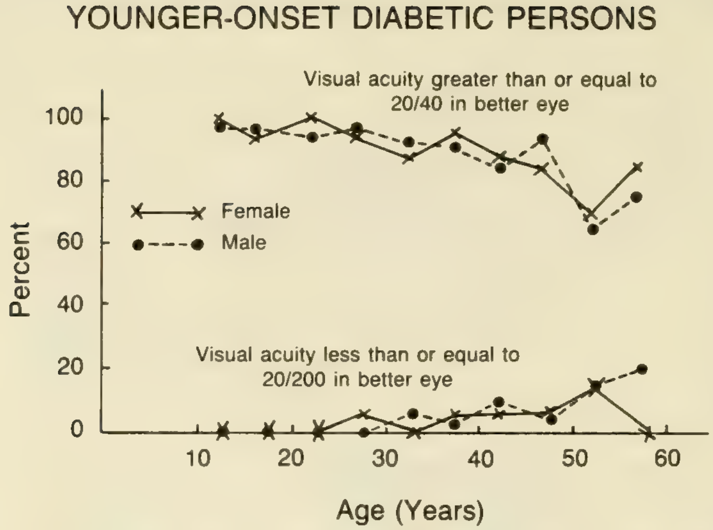

FIGURE 2. *The relationship of prevalence of no visual impairment or legal blindness to current age and sex in 996 insulin-taking persons diagnosed as having onset of diabetes prior to 30 years of age examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

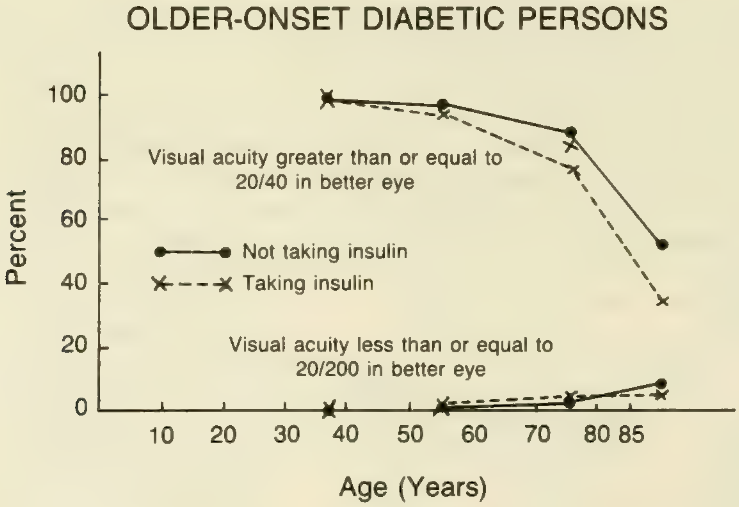

FIGURE 3. *The relationship of prevalence of no visual impairment or legal blindness to current age and sex in 1,365 insulin-taking and noninsulin-taking persons diagnosed as having onset of diabetes at 30 years of age or older examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

diabetic patients in the WESDR were higher than those estimated for the general United States population in the Health and Nutrition Examination Survey (HANES) or for all participants in the Framingham Eye Study (FES) (Figure 4).

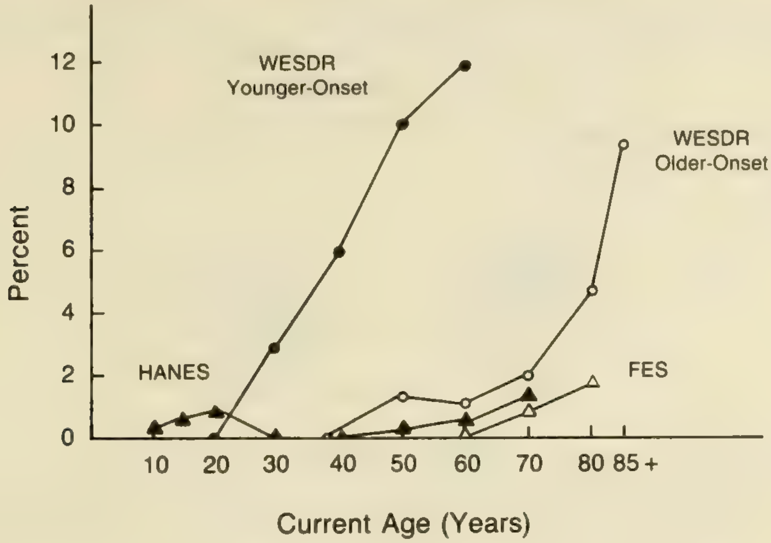

FIGURE 4. *Percent of persons with visual acuity of 20/200 or worse in better eye by current age in the diabetic population examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy and in the general populations examined in the Health and Nutrition Examination Survey (HANES) and in the Framingham Eye Study (FES)*

SOURCES: Klein, R, BEK Klein, SE Moss, et al. Visual impairment in diabetes. Ophthalmology 91:1-9, 1984. Roberts, J. Monocular visual acuity of persons 4 to 74 years, United States, 1971-72. National Center for Health Statistics, Vital and Health Statistics Series 11, No. 201, 1977. Leibowitz, HM, DE Krueger, LR Maunder, et al. The Framingham Eye Study Monograph. An ophthalmological and epidemiologic study of cataract, glaucoma, diabetic retinopathy, macular degeneration, and visual acuity in a general population of 2,631 adults, 1973-75. Surv Ophthalmol 24(Suppl):335-610, 1980.

Legal blindness was related to duration of diabetes in both younger- and older-onset participants in the WESDR (Figures 5, 6). In the younger-onset group, legal blindness first occurred in persons having diabetes about 15 years or more and increased from 3 percent in those with 15 to 19 years duration to 12 percent in persons with diabetes for 30 or more years. In the older-onset group, rates of legal blindness were lower, only reaching 7 percent in persons having diabetes for 20 to 24 years.

Diabetic retinopathy was partially or totally responsible for visual loss (acuity of 20/200 or worse) in 86 percent of eyes of younger-onset persons (Figure 7). Diabetic retinopathy was less often a cause of visual impairment in the older-onset patients; other causes of visual impairment, such as macular degeneration or cataracts, were more frequently responsible in this group of persons.

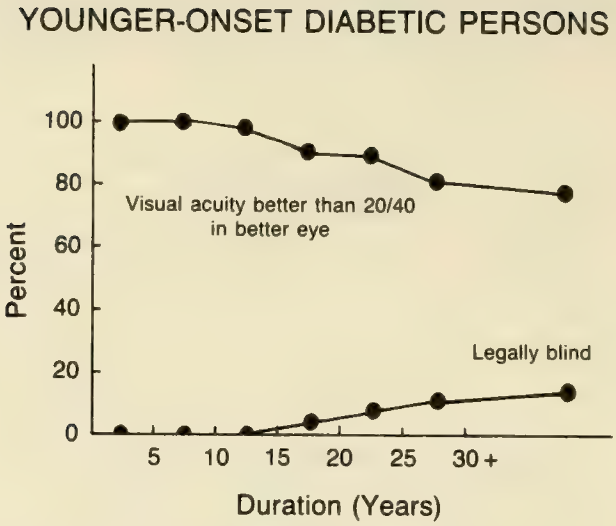
YOUNGER-ONSET DIABETIC PERSONS

FIGURE 5. *Percent of persons with visual acuity of 20/40 or better and those with legal blindness by duration of diabetes in 996 insulin-taking persons diagnosed as having diabetes prior to 30 years of age examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1 1980-82)*

SOURCE: Klein, R, BEK Klein, SE Moss, et al. Visual impairment in diabetes. Ophthalmology 91:1-9, 1984.

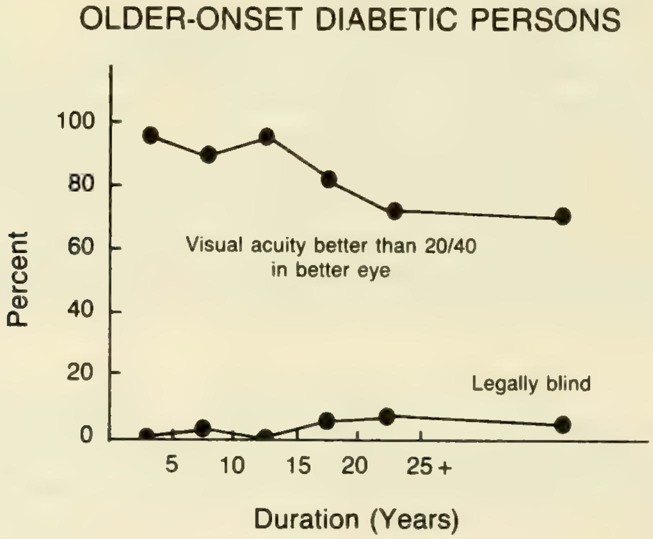
OLDER-ONSET DIABETIC PERSONS

FIGURE 6. *Percent of persons with visual acuity of 20/40 or better and of those with legal blindness by duration of diabetes in persons diagnosed as having diabetes at 30 years of age or older examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R, BEK Klein, SE Moss, et al. Visual impairment in diabetes. Ophthalmology 91:1-9, 1984.

In a study in Poole, England, 2 percent of 449 noninsulin-taking persons, and 1 percent of 212 insulin-taking diabetic persons, were found to be legally blind (Houston 1982).

Incidence

In data from the MRA registries, the highest incidence of new cases of legal blindness due to diabetes occurred in persons 45 to 64 years of age (Table 4). As with the

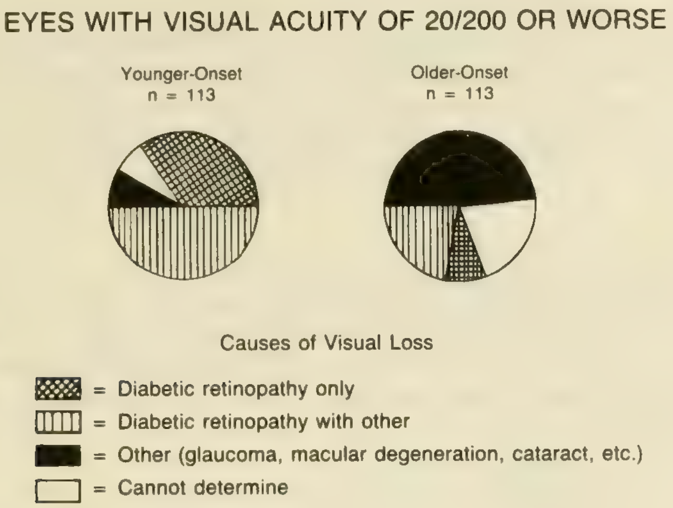

FIGURE 7. *Causes of visual loss (visual acuity of 20/200 or worse) in eyes of younger- and older-onset persons participating in the Wisconsin Epidemiologic Study of Diabetic Retinopathy*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

TABLE 4. *Incidence of legal blindness by age and sex due to diabetes and diabetic retinopathy, United States, 1978*

Age and Sex	Number of New Cases of Legal Blindness Due to Diabetes Per Year	Percent of Total New Cases of Legal Blindness Due to Diabetes	Number of New Cases of Legal Blindness Due to Diabetic Retinopathy	Percent of Total New Cases of Legal Blindness Due to Diabetic Retinopathy
Age (years)				
<5	0	0	0	0
5-19	<50	<0.1	<50	<0.1
20-44	700	13.4	600	11.5
45-64	2,450	22.6	2,050	18.9
65-74	1,750	21.5	1,350	16.6
75-84	800	7.0	600	5.3
85+	100	1.7	100	1.7
Sex				
Males	2,350	11.0	2,100	9.8
Females	3,450	13.7	2,600	10.3
Total	5,800	12.4	4,700	10.1

SOURCE: National Society to Prevent Blindness. Vision Problems in the United States, 1978. Estimated from 1970 Model Reporting Area data.

prevalence data, the relative proportion of cases due to diabetic retinopathy decreased with age; in these data there is an exception to the trend in those 85 and over. Rates for females were higher than rates for males. Of new cases of legal blindness, 12.4 percent was attributed to diabetes, the majority due to diabetic retinopathy. Diabetic retinopathy was the third most common diagnosis responsible for legal blindness in persons of all ages and was the leading cause of new cases of blindness in persons 20 to 74 years of age (Table 5).

In persons aged 20 to 79 with noninsulin-dependent diabetes who participated in the University Group Diabetes Program (UGDP), the 5-year incidence of legal blindness was 3.8 percent or less in each treatment group (Table 6). The incidence of legal blindness (visual acuity of less than 20/200) in either eye was 9.4 percent or less in each treatment group at the 5-year followup and rose to about 12 percent at the 12-year followup.

Caird et al. (1968) reviewed data from the Radcliffe Infirmary Diabetes Clinic in England. They estimated that for insulin-taking diabetic patients diagnosed at 20 years of age, the incidence of blindness was 0.1 percent after 10 years, 1.6 percent after 20 years, and 3.5 percent after 30 years of diabetes. For persons diagnosed at 60 years of age, the incidence of blindness was 1.8 percent after 10 years and 5.5 percent after 20 years of diabetes.

Untreated eyes with high risk characteristics in the Diabetic Retinopathy Study (DRS) had a cumulative incidence of severe visual loss (less than 5/200) of 14 percent at 2 years, 27 percent at 4 years, and 37 percent at 6 years (Figure 8). Panretinal photocoagulation was found to reduce the rate of severe visual loss by 50 percent or more.

Risk Factors for Development of Vision Loss and Blindness

Age at onset and duration of diabetes. All of the studies described above indicate that early age at onset and longer duration of diabetes are well-recognized risk factors for visual impairment in diabetic persons.

Sex. Analysis of MRA registry data indicate that the highest rates of legal blindness due to diabetes occurred in nonwhite females; nonwhite males and white females were intermediate, and white males had the lowest rates (Kahn and Hiller 1974). These prevalence data need to be verified by data on incidence by race and sex.

Severity of retinopathy. In a study of an English clinic population, eyes with more severe retinopathy were found to be at higher risk of blindness (Caird et al. 1968). The cumulative 5-year rate of blindness (vision 20/200 or worse) for eyes with good vision (20/60 or better) at the beginning of the study was 1.6 percent if retinopathy was not present, 1.3 percent if only retinal microaneurysms were present, and 14.8 percent if retinal blot hemorrhages and/or exudates were present. The relative risk of blindness in diabetic patients with retinopathy compared to the general population was estimated to be 29. Among 51 IDDM patients with proliferative retinopathy, followed in the Steno Hospital in Denmark, 50 percent had become legally blind after 5 years (Deckert et al. 1967). Since these studies reported the visual prognosis in the era before panretinal photocoagulation treatment was widely available, they may overestimate the current incidence of blindness attributable to diabetes.

Control of blood glucose. Caird and Garrett (1963) reported no relationship of visual deterioration to the control of diabetes as measured by a glycosuria index.

TABLE 5. *Leading causes of new cases of legal blindness, by age and sex, United States, 1978*

Age, Sex, and Cause	Number	Percent	Rate*
TOTAL			
1. Macular degeneration	7,850	16.8	3.5
2. Glaucoma, except congenital	5,350	11.5	2.4
3. Diabetic retinopathy	4,700	10.1	2.1
4. Senile cataract	4,550	9.8	2.0
5. Optic nerve atrophy	2,000	4.3	0.9
All other	22,150	47.5	10.0
Total	46,600	100.0	21.0
Under 5 years of age			
1. Prenatal cataract	250	16.7	1.6
2. Optic nerve atrophy	200	13.4	1.3
3. Retrolental fibroplasia	150	10.0	0.9
All other	900	59.9	5.9
Total in age group	1,500	100.0	9.8
5-19 Years of age			
1. Optic nerve atrophy	450	12.3	0.8
Prenatal cataract	450	12.3	0.8
2. Albinism	300	8.2	0.5
Myopia	300	8.2	0.5
Macular degeneration	300	8.2	0.5
3. Nystagmus	250	6.8	0.4
4. Retinitis pigmentosa	200	5.5	0.3
All other	1,400	38.4	2.5
Total in age group	3,650	100.0	6.5
20-44 Years of age			
1. Diabetic retinopathy	600	11.5	0.8
2. Optic nerve atrophy	450	8.6	0.6
Retinitis pigmentosa	450	8.6	0.6
3. Optic neuritis	300	5.8	0.4
Macular degeneration	300	5.8	0.4
All other	3,100	59.7	4.0
Total in age group	5,200	100.0	6.6
45-64 Years of age			
1. Diabetic retinopathy	2,050	18.9	4.7
2. Glaucoma, except congential	1,500	13.8	3.4
3. Senile cataract	1,250	11.6	2.8
4. Macular degeneration	700	6.4	1.6
5. Retinitis pigmentosa	550	5.1	1.2
6. Optic nerve atrophy	450	4.1	1.0
All other	4,350	40.1	9.9
Total in age group	10,850	100.0	24.7
65-74 years of age			
1. Diabetic retinopathy	1,350	16.6	9.0
2. Glaucoma, except congenital	1,300	16.0	8.7
Macular degeneration	1,300	16.0	8.7
3. Senile cataract	800	9.8	5.4
All other	3,400	41.6	22.8
Total in age group	8,150	100.0	54.6
75-84 years of age			
1. Macular degeneration	3,450	30.5	49.9
2. Glaucoma, except congenital	1,700	15.0	24.6
3. Senile cataract	1,300	11.4	18.8
4. Diabetic retinopathy	600	5.3	8.7
All other	4,300	37.8	62.2
Total in age group	11,350	100.0	164.2
85 Years of age and over			
1. Macular degeneration	1,800	30.5	81.6
2. Senile cataract	1,200	20.3	54.4
3. Glaucoma, except congenital	650	11.0	29.5
All other	2,250	38.2	102.0
Total in age group	5,900	100.0	267.5
65 Years of age and over			
1. Macular degeneration	6,550	25.8	27.2
2. Glaucoma, except congenital	3,650	14.3	15.2
3. Senile cataract	3,300	13.0	13.7
4. Diabetic retinopathy	2,050	8.1	8.5
All other	9,850	38.8	40.9
Total in age group	25,400	100.0	105.6
Males			
1. Macular degeneration	2,900	13.5	2.7
2. Glaucoma, except congenital	2,600	12.1	2.5
3. Diabetic retinopathy	2,100	9.8	2.0
4. Senile cataract	1,550	7.2	1.5
5. Optic nerve atrophy	1,250	5.8	1.2
All other	11,000	51.6	10.4
Total males	21,400	100.0	20.2
Females			
1. Macular degeneration	4,950	19.6	4.4
2. Senile cataract	3,000	11.9	2.7
3. Glaucoma, except congential	2,750	10.9	2.5
4. Diabetic retinopathy	2,600	10.3	2.3
5. Optic nerve atrophy	750	3.0	0.7
All other	11,150	44.3	10.0
Total females	25,200	100.0	22.5

*Number per 100,000 population in each age group and sex.

SOURCE: National Society to Prevent Blindness. Vision Problems in the United States, 1978. Estimated from 1970 Model Reporting Area data.

TABLE 6. *Incidence of various ocular complications in diabetic patients participating in the University Group Diabetes Program (UGDP)*

	Followup Time (Years)	Placebo		Tolbutamide		Insulin Standard		Insulin Variable	
		No.	Percent	No.	Percent	No.	Percent	No.	Percent
Legal blindness	5	186	2.7	188	3.7	188	1.6	184	3.8
Visual acuity <20/200 either eye	5	179	6.7	181	9.4	179	5.6	175	5.7
	12	180	11.7	--		180	12.2	174	12.1
Glaucoma*		167	12.0	--		175	8.0	169	7.7
Nonproliferative diabetic retinopathy (NPDR) (mild retinal abnormalities)	12	144	32.6	--		155	29.0	138	31.9
Severe NPDR or proliferative retinopathy	12	147	2.0	--		155	4.5	138	2.9
Photocoagulation	12	188	1.1	--		195	1.0	182	1.1

*Glaucoma obtained by history, at the 1967 followup examination.

SOURCE: University Group Diabetes Program. A study of the effects of hypoglycemic agents on vascular complications in patients with adult-onset diabetes. Diabetes 31(Suppl 5):1-81, 1982.

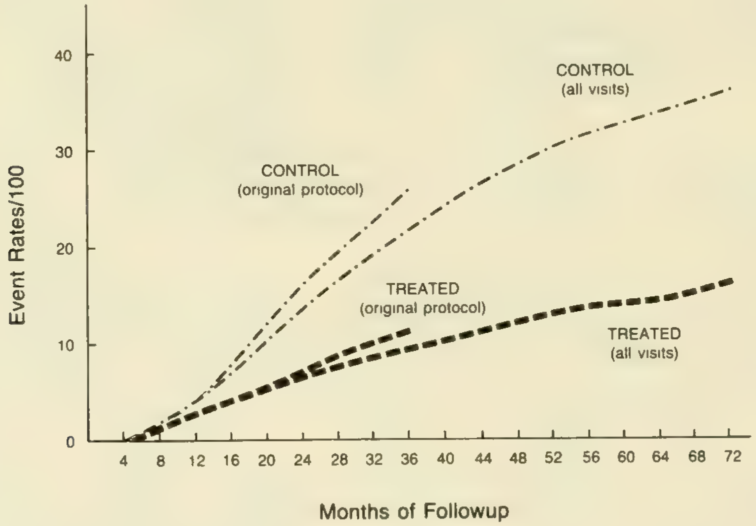

FIGURE 8. *Cumulative rates of severe visual loss (event rates/100) in eyes of patients participating in the Diabetic Retinopathy Study (DRS), including and excluding observations made after the 1976 protocol change, argon and xenon groups combined (treated) and control (untreated)*

SOURCE: Diabetic Retinopathy Study Research Group. Photocoagulation treatment of proliferative diabetic retinopathy. Clinical application of Diabetic Retinopathy Study (DRS) findings. DRS Report No. 8. Ophthalmol 88:583-600, 1981.

Rehabilitation and Economic Costs of Blindness

A number of sources for aids, appliances, and other information for the visually impaired are listed in Appendix A.

The demographic characteristics of those who are visually impaired and in need of rehabilitative services are not available. Also lacking are estimates of the costs resulting from visual impairment due to diabetes. Palmberg (1977) reported a crude estimate of lost income and public welfare expense related to blindness in diabetic persons to be $75 million annually, an estimate based on data from the early 1970s. In a sample survey of the United States in 1977, 16 percent of diabetics reported that they had an expense for vision care; their average expense was $82 per person in that year and the total expense for this group was $59 million (Meyers et al. 1983).

Visual Acuity as a Predictor of Death

The relationship between visual acuity and the probability of survival in insulin-taking diabetics seen in an eye clinic in Wisconsin is presented in Figure 9. The probability of survival declined with decreasing levels of visual acuity. The observed 5-year survival was approximately 40 percent in persons who were legally blind.

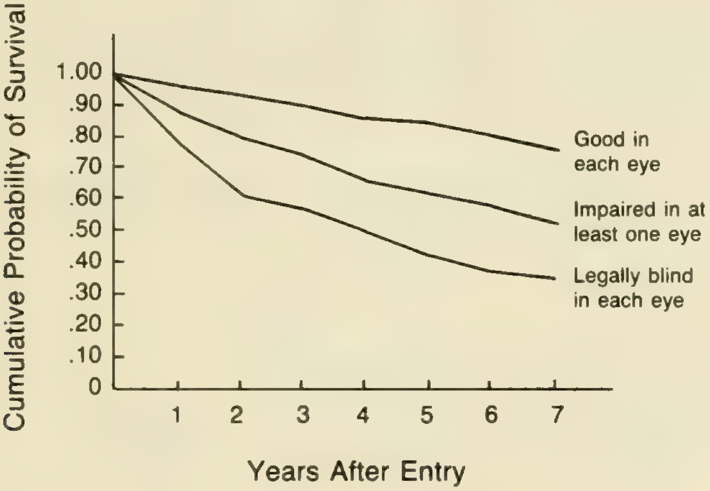

FIGURE 9. *Observed survival for 699 insulin-taking Wisconsin clinic patients with diabetes diagnosed under age 50, classified by visual acuity*

SOURCE: Davis, MD, R Hiller, YL Magli, et al. Prognosis for life in patients with diabetes in relation to severity of retinopathy. Trans Am Ophthalmol Soc 77:144-70, 1979.

Needs

Population-based incidence data to define risk variables and estimates of the relative importance of these factors in determining visual impairment are needed. Data about the problems of the visually impaired with respect to occupational, vocational, psychosocial, and medical care are necessary in order to describe adequately the current status and to project future health care delivery needs.

DIABETIC RETINOPATHY

Diabetic retinopathy is characterized by specific alterations in the appearance of the retina. The earliest change that can be seen with the aid of the ophthalmoscope is the retinal microaneurysm. Retinal blot hemorrhages, hard exudates, cotton-wool spots, intraretinal microvascular abnormalities, venous beading, and venous reduplication are other lesions that may be found in the nonproliferative phase of diabetic retinopathy. Proliferative retinopathy is characterized by the growth of abnormal blood vessels and fibrous tissue from the optic nerve head or from the inner retinal surface elsewhere. Swelling of the macular region of the retina, called macular edema, may occur in the presence of either nonproliferative or proliferative retinopathy.

Prevalence and Associated Risk Factors

In the WESDR, stereoscopic fundus photographs of seven standard photographic fields were taken of each eye. Objective grading of retinopathy by standard protocols was used to assure reproducible assessment and classification of retinopathy severity (ETDRS 1980, R Klein et al. 1984c). Seventy-one percent of younger-onset persons (onset before age 30 years) had retinopathy, and 22.5 percent had proliferative retinopathy. The prevalence and severity of diabetic retinopathy increased with increasing age in younger-onset persons (Figure 10). Prior to 13 years of age, diabetic retinopathy was infrequent, irrespective of the duration of the disease.

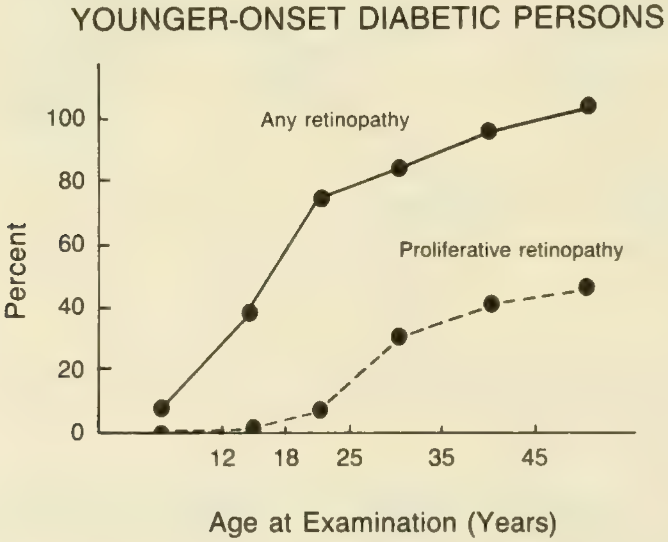

FIGURE 10. *Prevalence of any or proliferative retinopathy, by age at examination, in 995 insulin-taking persons diagnosed as having diabetes prior to 30 years of age examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

For younger-onset persons, both the frequency and severity of retinopathy increased with increasing duration of diabetes (Figure 11). The prevalence of retinopathy 5 years after the diagnosis of diabetes was 14.5 percent in males and 24.3 percent in females, and in all cases it was mild. On the other hand, in persons with diabetes for 19 to 20 years, 50 percent of males and 33 percent of females had proliferative retinopathy. The relative risk for the presence of proliferative retinopathy in males compared to females with 10 or more years of diabetes was 1.26 (Appendix B). The reason for this sex difference is unknown. It may reflect selective survival; perhaps females with worse retinopathy died.

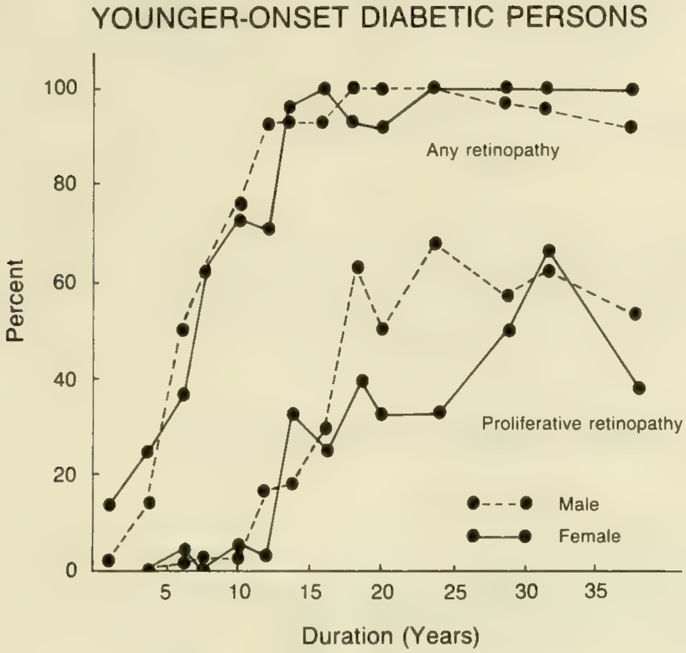

FIGURE 11. *Prevalence of any or proliferative diabetic retinopathy, by sex and duration, in 995 insulin-taking persons diagnosed as having diabetes prior to 30 years of age examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

The severity of retinopathy was associated with higher glycosylated hemoglobin level (Figure 12) and higher diastolic blood pressure level (Figure 13), but not with current insulin usage patterns (neither the type of insulin nor the number of units) nor with family history of diabetes (Appendix B).

There was no excess risk of retinopathy in smokers or ex-smokers when contrasted with those who never smoked (R Klein et al. 1983). The relative risk for the presence of retinopathy in smokers compared to those who had never smoked was 1.21 (Appendix B). There was no relationship between the severity of retinopathy and number of

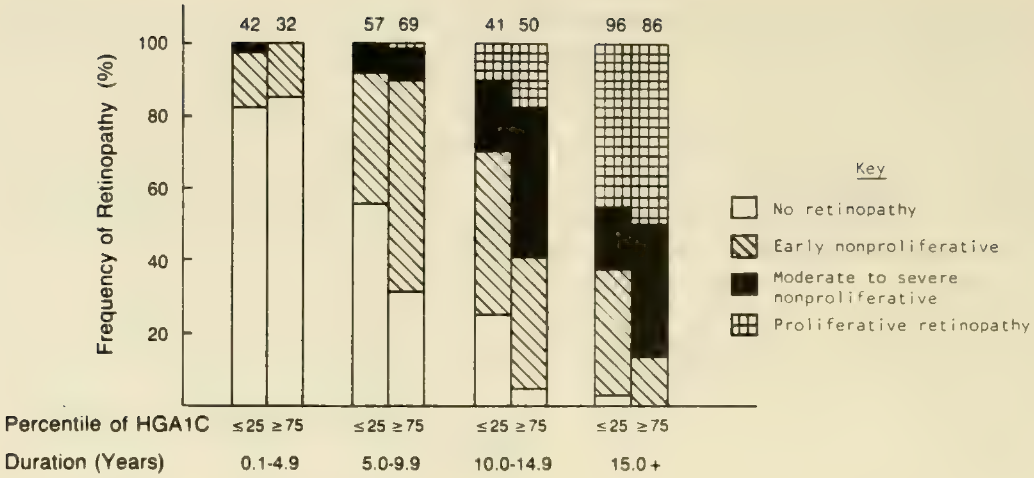

FIGURE 12. *The relationship of the frequency and severity of diabetic retinopathy to glycosylated hemoglobin level, by duration of diabetes, in 995 insulin-taking persons diagnosed as having diabetes prior to 30 years of age in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

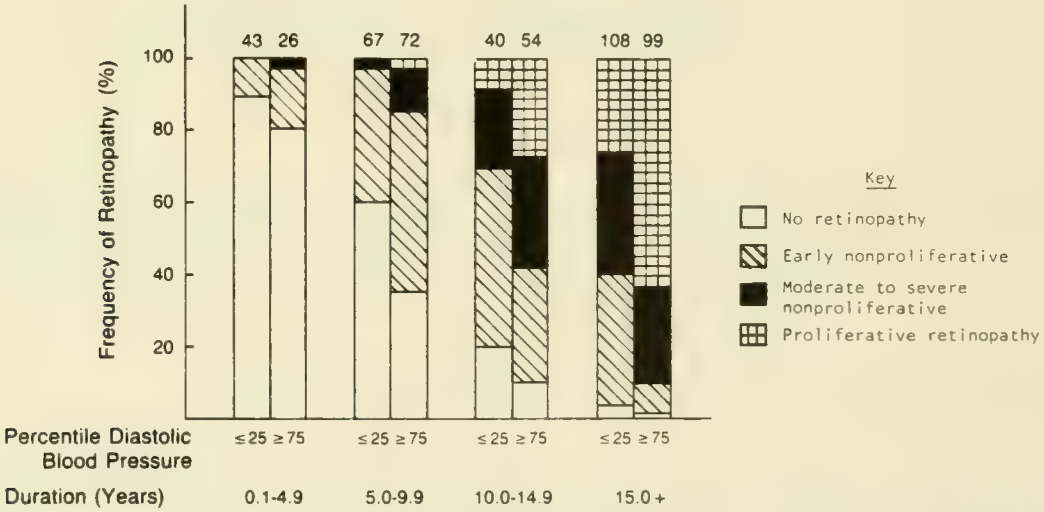

FIGURE 13. *The relationship of the frequency and severity of diabetic retinopathy to diastolic blood pressure level, by duration of diabetes, in 995 persons diagnosed as having diabetes prior to 30 years of age participating in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

cigarettes smoked daily, or the number of pack-years smoked while diabetic. This may reflect the real absence of a relationship, or there may be selective mortality of smokers with more severe retinopathy.

In older-onset persons in the WESDR, 39 percent of those persons who did not take insulin, and 70 percent of those who did, had retinopathy; 3 percent of the former and 14 percent of the latter had proliferative retinopathy (R Klein et al. 1984). In these older-onset persons, the prevalence rates of retinopathy did not increase consistently with age (Figure 14).

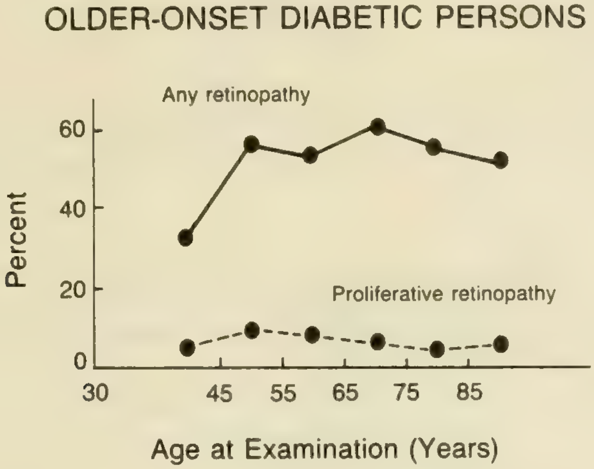

FIGURE 14. *The relationship of any or proliferative retinopathy to age at examination in 1,365 persons diagnosed as having diabetes at 30 years of age or older participating in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

In older-onset persons in the WESDR, prevalence and severity of retinopathy increased with increasing duration of diabetes (Figure 15). In males and females with fewer than 3 years of diabetes, the rates of retinopathy were 22 percent and 27 percent higher, respectively, than the rates for younger-onset patients with similar duration of diabetes. In older-onset persons with 19 to 20 years duration, 75 percent of females and 83 percent of males had retinopathy, and 20 percent had proliferative diabetic retinopathy (Figure 15).

The presence of retinopathy was associated with age at diagnosis of diabetes, type of hypoglycemic regimen used, glucose control as measured by glycosylated hemoglobin level, systolic blood pressure, and proteinuria in older-onset persons in the WESDR (Appendix C). No associations between severity of retinopathy and cigarette smoking history (R Klein et al. 1983) or family history of diabetes were found. There was no excess risk of retinopathy in older-onset smokers or ex-smokers when contrasted with those who never smoked. The relative risk for the presence of retinopathy in smokers compared to those who had never smoked was 0.61, 0.84, and 0.92 for persons with 0 to 4, 5 to 14, or 15 or more years of diabetes respectively (Appendix C). There was no relationship between the severity of retinopathy and number of cigarettes smoked daily or the number of pack-years smoked while diabetic. As in the younger-onset persons, selective mortality of smokers with more severe retinopathy may account for this finding.

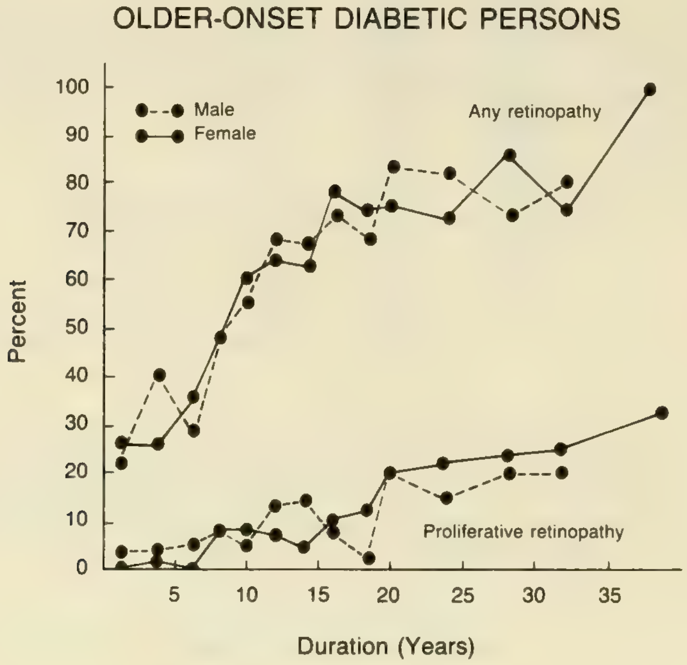

FIGURE 15. *The relationship of prevalence of any or proliferative retinopathy to sex and duration of diabetes in persons diagnosed as having diabetes at 30 years of age or older participating in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

Pregnancy and Diabetic Retinopathy

Data concerning the role of pregnancy and progression of diabetic retinopathy have been derived from clinics caring for large numbers of diabetic patients. Of 2,000 cases of "obstetrical" diabetes followed at the Joslin Clinic from 1897 to 1965, "proliferating" retinopathy was no worse in 22 women who had experienced pregnancy during the course of insulin-dependent diabetes than in a matched control group (White 1965). The question of whether retinopathy progression is accelerated during the course of pregnancy is not answered.

In the WESDR, women were queried concerning the number of past pregnancies. There was no increase in severity of retinopathy with increasing number of past pregnancies (Klein and Klein 1984).

Prevalence Data From Other Studies

Prevalence data have been reported in other population-based studies. In the FES, the number of diabetic persons was small (fewer than 300 persons) and the age was limited to persons 52 years or older (Leibowitz et al. 1980). The overall prevalence of retinopathy in persons with diabetes was 19.3 percent (Table 7). Examination of the eyes of 1,640 Pima Indians whose ages were 15 and over was performed as part of the visual evaluation of that population (Knowler et al. 1980). Eighteen percent of diabetic persons (diabetes defined as a 2-hour postload plasma glucose of 200 mg/dl or greater) were found to have retinopathy. The prevalence of retinopathy increased from 3 percent among Pimas who were newly diagnosed to 47 percent among those with 10 or more years of diabetes. After controlling for the duration of diabetes, no relationship between prevalence of retinopathy and age at diagnosis, age at time of examination, or sex was found. In the Poole, England study, the prevalence of diabetic retinopathy was not associated with age at examination, but was related to known duration of diabetes (Houston 1982). The prevalence of proliferative ("complex") retinopathy increased with duration in insulin-treated patients but not in diabetic persons who were not treated with insulin.

TABLE 7. *Prevalence of retinopathy in persons with history of diabetes examined in the Framingham Eye Study (FES)*

Current Age at FES (Years)	Total Number With Diabetes	Number With Retinopathy	Percent With Retinopathy
52-65	100	18	18.0
65-74	95	16	16.8
75+	54	14	25.9
Total	249	48	19.3

SOURCE: Leibowitz, HM, DE Krueger, LR Maunder, et al. The Framingham Eye Study Monograph. Surv Ophthalmol 24(Suppl):335-610, 1980.

Incidence

There is a paucity of population-based data concerning the incidence and progression of retinopathy. Cumulative incidence rates of retinopathy in patients followed from 1945 to 1969 in Rochester, Minnesota are presented in Figure 16 (Palumbo and Melton 1984). Of persons with 20 years duration of diabetes (type unspecified), approximately 42 percent of females and 48 percent of males had developed retinopathy. These findings may underestimate the actual incidence of retinopathy, since detection was by ophthalmoscopy done during routine medical examination.

An incidence of retinopathy of 24 percent in 6 years has been reported in the noninsulin-taking Pima Indian population (Knowler et al. 1980). Increased incidence was associated with longer duration of diabetes, higher plasma glucose levels, presence of proteinuria, and higher systolic blood pressure levels. Insulin-taking Pima Indians were at higher risk of developing retinopathy than noninsulin-taking Pimas.

Other incidence data have been reported from select patient groups (Burditt et al. 1968, BEK Klein et al. 1984b, UGDP 1982). Higher incidence of new retinopathy (determined by direct ophthalmoscopy) and greater progression of retinopathy have been reported in persons with longer duration of diabetes (type unspecified) in a retrospective cohort study in the Radcliffe Diabetic Clinic (Tables 8 and 9). Good control, as measured by a glycosuria index prior to the onset of retinopathy, was associated with lower incidence. However, after retinopathy had developed, there was no association between control and progression of retinopathy.

In another study, 191 insulin-taking patients with at least 5 years of diabetes had fundus photography initially and 2 and 6 years later (BEK Klein et al. 1984b). Of those who initially had no retinopathy, 21 percent (7/33) developed retinopathy after 2 years and 71 percent (30/35) developed retinopathy after 6 years. For persons who had retinopathy initially, the retinopathy progressed in 18.3 percent at 2 years and 53 percent at 6 years. Hence, longer duration of diabetes was associated with increased risk of retinopathy developing and progressing.

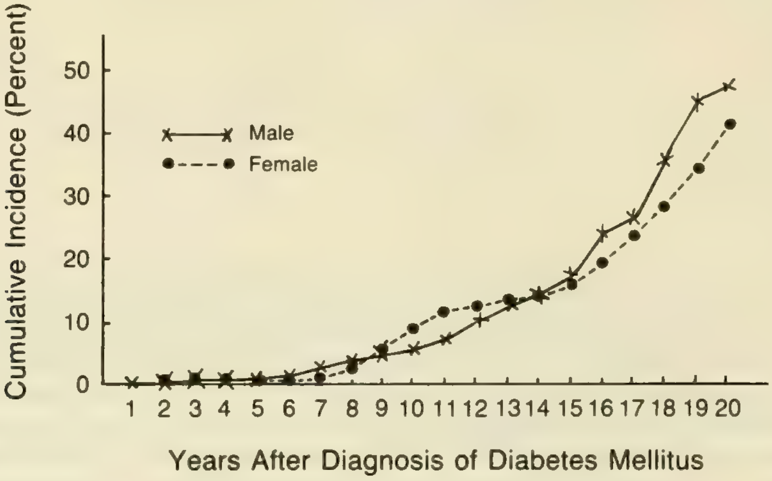

FIGURE 16. *Cumulative incidence of retinopathy, by sex*

SOURCE: Palumbo, P, and LJ Melton. Unpublished data, Rochester, Minnesota, 1945-69.

TABLE 8. *Chances of development of retinopathy in patients with normal fundi*

Age at Diagnosis of Diabetes (Years)	Duration of Diabetes at First Observation (Years)	Percent (Number) Developing Retinopathy in Interval After First Observation		
		0-4 Years	5-9 Years	10+ Years
0-29	0-4	8 (2/25)	23 (7/30)	32 (9/28)
	5-9	71 (5/7)	67 (6/9)	33 (3/9)
30-59	0-4	33 (30/91)	44 (66/151)	40 (22/55)
	5-9	51 (17/33)	40 (10/25)	18 (2/11)
60+	0-4	39 (28/71)	37 (25/67)	12 (2/17)
	5-9	33 (4/12)	43 (5/12)	(0/1)

SOURCE: Burditt, AF, FI Caird, and GJ Draper. The natural history of diabetic retinopathy. QJ Med 37:303-17, 1968.

TABLE 9. *Chances of progression of retinopathy*

Retinopathy at First Observation	Age at Diagnosis of Diabetes (Years)	Duration of Diabetes at First Observation (Years)	Percent (Number) Progression in Interval After First Observation	
			0-4 Years	5-9 Years
Microaneurysms alone	0-29	All	44 (12/27)	40 (4/10)
	30-59	All	63 (31/49)	63 (10/16)
	60+	All	43 (7/16)	(2/4)
Hemorrhages and/or exudates	0-29	All	10 (5/27)	10 (1/10)
	30-59	All	7 (5/73)	18 (10/55)
		0-9	9 (4/46)	23 (10/44)
		10-19	4 (1/27)	0 (0/11)
	60+	All	0 (0/47)	14 (2/14)

SOURCE: Burditt, AF, FI Caird, and GJ Draper. The natural history of diabetic retinopathy. Q J Med 37:303-17, 1968.

In two prospective randomized clinical trials comparing subcutaneous insulin infusion systems (CSII) with conventional treatment, the blood sugars have been successfully lowered in the CSII group compared to the CT group (Lauritzen et al. 1983, Kroc Collaborative Group 1984). However, in both groups there was significant progression of retinopathy over an 8-month-to-2-year interval. Conclusions drawn from these studies are limited due to the small sample and the short period of followup time. In addition, these studies included no patients without retinopathy; thus, the question of prevention of development of retinopathy by metabolic control has not been answered.

In persons with noninsulin-dependent diabetes who participated in the UGDP, the 12-year incidence of mild nonproliferative retinopathy (determined by reviewing retinal photographs) was 29 percent in the insulin standard, 31.9 percent in the insulin variable, and 32.6 percent in the placebo groups (UGDP 1982). Incidence rates for severe nonproliferative or proliferative retinopathy varied from 2 percent to 4.5 percent (Table 6).

Data concerning the incidence and progression of retinopathy have been limited by the size or the select nature of the populations studied, systematic intervention, failure to use standardized protocols, inconsistent followup times, selective dropout, and the failure to use objective recording of retinopathy. Information from the previous studies may not be generalizable to larger unselected populations of diabetic patients.

Prognostic Factors and Therapeutic Trials

In order to relate the risk of new development or progression of diabetic retinopathy to antecedent characteristics such as blood pressure level, blood glucose control, or cigarette smoking, incidence data are necessary. In addition, preventive trials for intervention on alterable risk factors are necessary to determine whether current medical therapeutics can prevent disease progression. Therapeutic intervention using aldose reductase inhibitors (multiclinic study of the effects of sorbinil, compared to placebo) (Pfizer 1983), aspirin (ETDRS 1980), and better control of blood glucose (the Diabetic Control and Complication Trial) (NIAMDD 1981) are currently being evaluated. The role of panretinal photocoagulation at an earlier stage of retinopathy and focal photocoagulation for macular edema are being studied in the Early Treatment

Diabetic Retinopathy Study (ETDRS 1980). Vitrectomy for early intervention after vitreous hemorrhage is being evaluated in the Diabetic Retinopathy Vitrectomy Study (1976).

Retinopathy as a Risk Factor

Retinopathy, because it can be visualized early in the course of diabetes, may be used as an indicator of vascular disease. For example, the severity of retinopathy in older-onset persons may provide descriptive and, possibly, prognostic information about cardiovascular and renal disease status. Oklahoma Indians with diabetic retinopathy were found to have a higher prevalence of coronary disease (West et al. 1980). The percentage of patients with electrocardiographic major Q waves was 9 percent in those without retinopathy, 15 percent with retinopathy, and 21 percent in those with severe retinopathy in this group. Further studies are necessary to evaluate these relationships. The relationship between severity of retinopathy, determined by using fundus photography, and the probability of survival in a clinic population of diabetic patients is presented in Figure 17. The probability of survival decreased with increasing severity of retinopathy. In persons with proliferative diabetic retinopathy, the observed 5-year survival rate was 56 percent. Similar rates have been found by others (Figure 18).

Population-based estimates of survival for specified severity levels of retinopathy are needed for accurate estimates of prognosis for life.

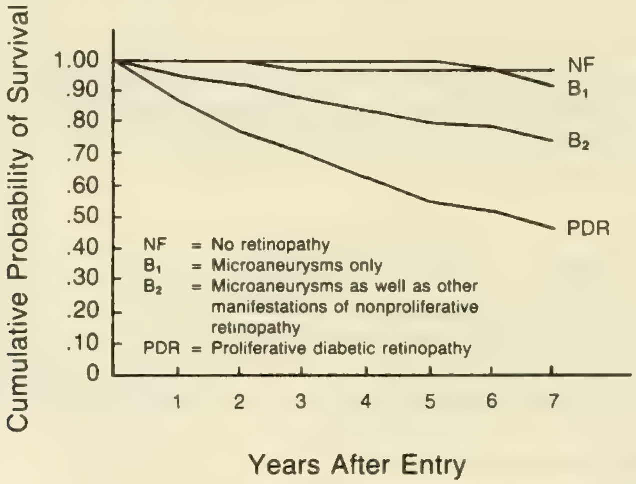

FIGURE 17. *Observed survival for 699 insulin-taking Wisconsin clinic patients with diabetes diagnosed under age 50, classified by severity of retinopathy in the more severely involved eye*

SOURCE: Davis, MD, R Hiller, YL Magli, et al. Prognosis for life in patients with diabetes: Relation to severity of retinopathy. Trans Am Ophthalmol Soc 77:144-70, 1979.

CATARACTS

Cataracts may be defined in any of several different ways. One commonly used definition depends upon the anatomic location of the opacity in the lens. This may be determined at examination or, less frequently, by examination of red reflex photographs of the lens. In addition, some studies (Leibowitz et al. 1980, USDHEW 1972) specify a level of visual acuity deficit in conjunction with lens opacities for the diagnosis of cataract. Surgical aphakia (absence of the lens after surgical extraction) has also been used as a measure of the presence of previous cataract (Schwab et al. 1983). Three anatomical descriptions of cataract that are frequently used are cortical, nuclear sclerotic, and posterior subcapsular.

Data from the 1976 NHIS indicate that the estimated rates of cataract, as determined by questioning the participants, increased with increasing age (Table 10). This held

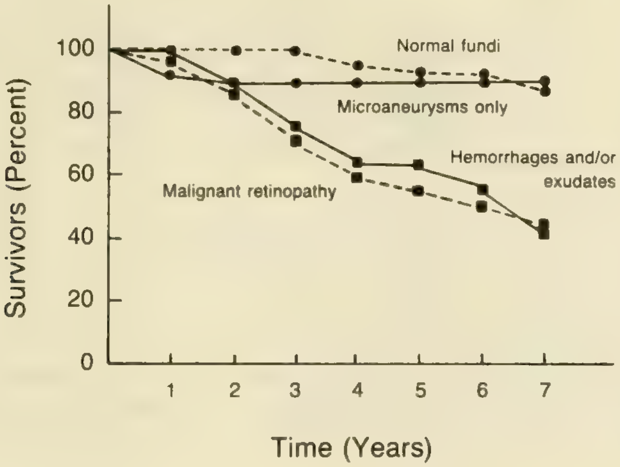

FIGURE 18. *Survival in relation to severity of retinopathy*

SOURCE: Caird, FI, A Pirie, and TG Ramsell. Diabetes and the Eye. Oxford and Edinburgh: Blackwell, 1968. p. 98.

TABLE 10. *Prevalence of certain eye conditions and impairments: Number of reported eye conditions per 1,000 persons, for diabetics and for all persons, United States, 1976-77*

	Age (Years)							
	20		20-44		45-64		65+	
Condition	DM	U.S.	DM	U.S.	DM	U.S.	DM	U.S.
Cataracts	121.4	36.9	21.0	4.5	73.4	26.4	216.5	165.4
Glaucoma	39.4	10.5	14.0	1.5	30.0	11.0	60.2	39.2
Visual impairment	218.8	75.2	106.1	35.8	152.8	68.2	343.9	220.2
Severe visual impairment	46.2	9.7	2.6	1.4	30.3	6.0	83.6	44.5

SOURCE: Harris, MI, and TF Drury, National Diabetes Data Group. Unpublished data from the 1976 and 1977 National Health Interview Surveys, National Center for Health Statistics.

true for diabetic persons (type unspecified) as well as for the nondiabetic United States adult population. Rates were higher for diabetic persons in each age group. In addition, for diabetic persons of all ages, the reported rate of cataract increased with increasing duration of diabetes (Figure 19).

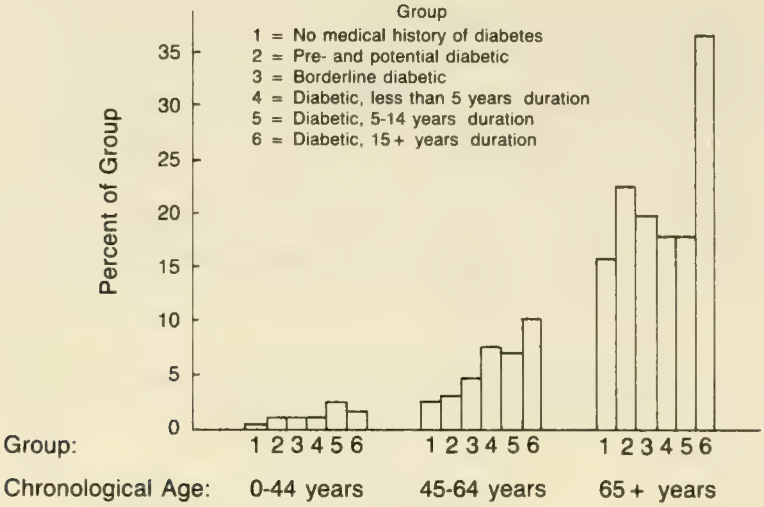

FIGURE 19. *The relationship of the reported prevalence of cataracts to chronological age and the presence and absence of diabetes, United States, 1976*

SOURCE: Harris, MI, National Diabetes Data Group. Unpublished data from the 1976 National Health Interview Survey, National Center for Health Statistics.

Rates of cataract determined at an ophthalmologic examination in the HANES and FES populations also increased with increasing age (USDHEW 1972). The rates are seen in Table 11 and Figure 20. In the FES, rates for diabetic persons 52 to 64 years of age were higher than for nondiabetic persons; there was little difference in older persons. In the HANES population, rates in diabetic persons were higher than in nondiabetic persons.

In the WESDR, cataract was determined by slit lamp examination and graded by comparison with standard photographs (BEK Klein et al. 1985). In younger- and older-onset diabetic persons, the frequency of cataract increased with increasing age. In younger-onset persons less than 45 years of age and in noninsulin-taking older-onset persons, rates of cataract in females were higher than in males (Table 12). In insulin-taking older-onset patients, the sex difference was not apparent.

Potential environmental exposures may affect rates of cataracts. Cotlier (1981) reported an inverse association between aspirin usage and frequency of cataract in diabetic patients. Seigel et al. (1982) failed to find a similar relationship in all participants in the FES.

TABLE 11. *Age, lens changes, and diabetic status of two study populations*

	Framingham				HANES			
	With Diabetes		Without Diabetes		With Diabetes		Without Diabetes	
Lens Change	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Subjects 50-64 Years Old*								
All persons	97	100.0	1,091	100.0	79	100.0	930	100.0
No senile lens change	36	37.1	593	54.4	52	65.8	678	72.9
Any senile lens change	61	62.9	498	45.6	27	34.2	252	27.1
Aphakia	3	3.1	14	1.3	2	2.5	8	0.9
Cataract**	4	4.1	11	1.0	8	10.1	31	3.3
Precataract	54	55.7	473	43.4	17	21.5	213	22.9
Subjects 65-74 Years Old								
All persons	87	100.0	666	100.0	162	100.0	1,476	100.0
No senile lens change	19	21.8	151	22.7	48	29.6	635	43.0
Any senile lens change	68	78.2	515	77.3	114	70.4	841	57.0
Aphakia	2	2.3	13	2.0	13	8.0	47	3.2
Cataract**	6	6.9	49	7.4	52	32.1	299	20.3
Precataract	60	69.0	453	68.0	49	30.2	495	33.5
Subjects 75-85 Years Old								
All persons	49	100.0	327	100.0	--	--	--	--
No senile lens change	4	8.2	27	8.3	--	--	--	--
Any senile lens change	45	91.8	300	91.7	--	--	--	--
Aphakia	4	8.2	30	9.2	--	--	--	--
Cataract**	13	26.5	72	22.0	--	--	--	--
Precataract	28	57.1	198	60.5	--	--	--	--

*The youngest Framingham subject was 52 years old.

**Excluding aphakia.

SOURCE: Ederer, F, R Hiller, and HR Taylor. Senile lens changes and diabetes in two population studies. Am J Ophthalmol 91:381-95, 1981.

Research Needs

Standard reproducible measures of the presence and severity of cataracts are necessary in order to pursue possible causal associations with respect to exposure to ultraviolet light, diet, levels of blood sugar control, and other potential risk factors.

GLAUCOMA

Glaucoma is a disease in which there is damage to the optic nerve fibers due to absolute or relative elevations in intraocular pressure. For the purposes of this section, glaucoma is defined as a history of this diagnosis, with or without the use of medication. No distinction is made between various types of glaucoma (open angle, closed angle, rubeotic, or other primary or secondary types).

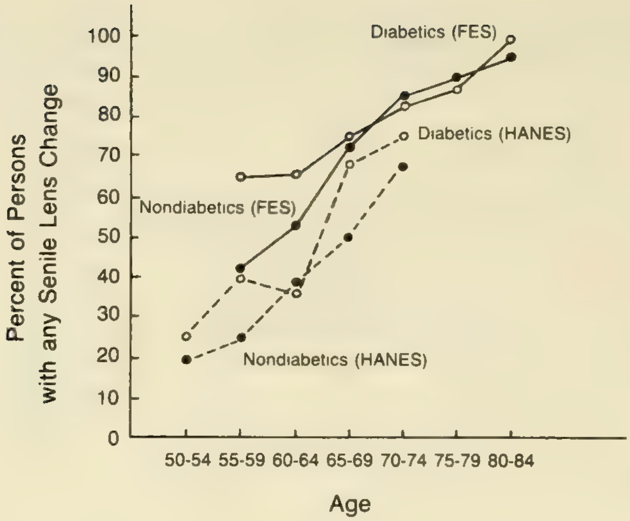

FIGURE 20. *Percentage of individuals with senile lens changes in one or both eyes: Framingham Eye Study (FES), and Health and Nutrition Examination Survey (HANES)*

SOURCE: Ederer, F, R Hiller, and HR Taylor. Senile lens changes and diabetes in two population studies. Am J Ophthalmol 91:381-95, 1981.

TABLE 12. *Prevalence of significant cataracts in either eye of younger- and older-onset diabetic persons examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

Age at Diagnosis (Years)	Age at Examination (Years)	Percent With Significant Cataracts	
		Females	Males
< 30 (Insulin-taker)	0-44	8.0	5.4
	45-64	32.2	33.3
	65+	-	-
≥ 30 (Insulin-taker)	30-44	6.8	6.8
	45-54	2.9	9.6
	55-64	16.2	18.5
	65-74	44.0	33.3
	75-84	49.5	57.5
	85+	55.6	71.1
≥ 30 (Noninsulin-taker)	30-44	.0	.0
	45-54	17.6	.0
	55-64	13.3	1.8
	65-74	27.8	23.2
	75-84	53.8	39.3
	85+	66.0	62.9

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

Data from the 1967-77 NHIS indicate that diabetic persons 20 years of age or older (type unspecified) reported substantially higher rates of glaucoma than did the nondiabetic United States population (Table 10). Rates of glaucoma increased with increasing age, with the highest reported rates occurring in persons 65 years of age or older. Rates of glaucoma among diabetic persons increased with increasing duration of diabetes (Figure 21).

In the WESDR younger-onset persons, the rate of glaucoma, as ascertained by history, increased with increasing age (BEK Klein et al. 1984a) (Table 13). In older-onset persons, rates of glaucoma also increased with age and were similar to those reported

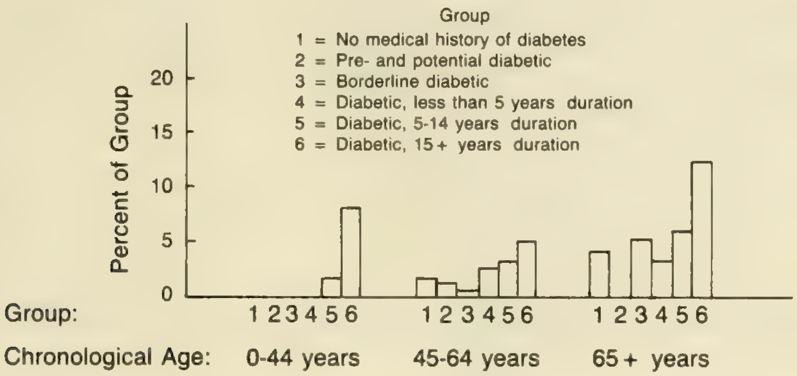

FIGURE 21. *The relationship between reported prevalence of glaucoma in nondiabetic and diabetic populations by chronologic age and duration of diabetes, United States, 1976*

SOURCE: Harris, MI, National Diabetes Data Group. Unpublished data from the 1976 National Health Interview Survey, National Center for Health Statistics.

TABLE 13. *Percentage distribution of glaucoma history by current age in younger- and older-onset diabetic persons examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

Age at Diagnosis (Years)	Age at Examination (Years)	Number	Glaucoma History	
			No	Yes
< 30	0-44	859	97.6	2.4
	45-64	125	90.4	9.6
	65+	12	83.3	16.7
	Total	996	96.5	3.5
≥ 30	30-44	49	98.1	1.9
	45-64	519	96.0	3.7
	65+	802	94.1	7.5
	Total	1,370	95.1	4.8

SOURCE: Klein, BEK, and R Klein. WESDR. Unpublished data, 1980-82.

in the 1976 NHIS. In both younger- and older-onset patients in the WESDR, rates of glaucoma increased with increasing duration of diabetes (Table 14). Similarly, in the FES, the prevalence of glaucoma was higher in persons having diabetes mellitus 15 years or longer, compared to persons who had diabetes for less than 5 years (Leibowitz et al. 1980).

TABLE 14. *Percent distribution of glaucoma history by duration of diabetes in younger- and older-onset diabetic persons examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

	Younger-Onset Diabetes		Older-Onset Diabetes	
Duration (Years)	Total Number	Percent With History of Glaucoma	Total Number	Percent With History of Glaucoma
0-4	172	0	354	3.7
5-9	246	0.4	338	5.0
10-14	174	1.7	181	4.4
15-19	134	3.7	251	8.0
20-24	88	9.1	161	8.1
25+	182	9.9	85	10.6
Total	996	3.5	1,370	5.8

SOURCE: Klein, BEK, and R Klein. WESDR. Unpublished data, 1980-82.

Incidence rates of glaucoma (by history) in Type II diabetic patients are available from the selected population that participated in the UGDP (1982). In that study, 5-year incidence rates varied between 7.7 and 12.0 percent (Table 6).

Research Needs

Accurate incidence rates and risk factors for glaucoma in diabetic and nondiabetic populations are lacking. These data are necessary to determine the need for care and to evaluate intervention strategies.

CORNEAL DISEASES

There is an absence of epidemiologic data concerning corneal problems in diabetic persons. In a study of 81 insulin-dependent patients attending a university hospital outpatient clinic, diabetic patients had significantly greater mean corneal thickness, measured by pachometry, than a nondiabetic group (Busted et al. 1981). Among diabetic patients, those with proliferative retinopathy had higher mean values than patients without retinopathy or those without proliferative changes. There were no fewer corneal endothelial cells in the diabetic than in the nondiabetic persons. In 89 diabetic patients followed at a university eye clinic, corneal epithelial defects were found in 64 percent of the patients, with lesions occurring more frequently in NIDDM as compared to IDDM patients (Schultz et al. 1981). Forty-seven percent of eyes were said to have "decreased" tear production, and 23 percent had "reduced" corneal sensation. Data were not provided for a matched nondiabetic control group.

It is important to determine the risk of corneal infections (corneal ulcers), scar formation, and degeneration, which may follow surgical treatment (cataracts, vitreal and retinal surgery), and which may, themselves, lead to visual impairment.

HEALTH CARE DELIVERY

In the 1973 NHIS, participants over 40 years of age were asked, "About how long has it been since you had your eyes examined?" and "How long has it been since you had a test for glaucoma?" No distinction was made between care by an ophthalmologist or an optometrist. Diabetic persons were more likely to have had an eye examination and a glaucoma test than nondiabetic persons (Table 15). Over 32 percent of diabetic patients stated that they had never had an eye pressure test. In a United States sample survey in 1977, 16 percent of diabetics reported that they had an expense for vision care in that year, compared to 11 percent of nondiabetic persons (Meyers et al. 1983).

TABLE 15. *Percent of persons by frequency of vision tests, United States, 1973*

	Age (Years)			
	40-64		65+	
Frequency of Test	Diabetic	Nondiabetic	Diabetic	Nondiabetic
Last glaucoma test				
Never had a test	35.7	38.5	32.6	40.0
Test within the past year	29.1	23.7	31.0	24.5
Within past two years	39.6	34.6	41.3	33.4
Two to five years ago	16.2	17.4	15.0	15.9
More than five years ago	4.4	4.2	6.8	5.8
Last eye exam				
Never had a test	3.1	4.1	2.0	3.4
Test within the past year	39.4	35.9	37.5	33.5
Within past two years	56.8	54.4	52.4	48.1
Two to five years ago	29.1	30.1	27.3	30.7
More than five years ago	9.3	9.0	15.6	15.1

SOURCE: Drury, TF. Unpublished data from the 1973 National Health Interview Survey, National Center for Health Statistics.

In the WESDR, participants were queried as to whether they had been seen by an ophthalmologist, and, if so, when they were last seen (Witkin and Klein 1984). Those who were never seen by an ophthalmologist were asked if they had received optometric care. Sixty-three percent of younger-onset and 50 percent of older-onset diabetic persons had seen an ophthalmologist within the past 2 years; 25 percent of younger- and 36 percent of older-onset persons had never had an ophthalmologic examination (Table 16).

Approximately 90 percent of younger-onset and 93 percent of older-onset persons with DRS high-risk characteristics for visual loss had been examined in the 2 years prior to the survey.

Since proliferative retinopathy is usually initially asymptomatic and may require treatment in order to prevent severe visual loss, it is necessary that it be correctly diagnosed. Internists, diabetologists, and senior medical residents were found to correctly diagnose the presence of proliferative retinopathy in 49 percent of cases they examined, whereas ophthalmologists and retinal specialists correctly diagnosed its presence in 96 percent of cases (Table 17).

TABLE 16. *Eye care for diabetic persons examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

	Younger-Onset		Older-Onset	
	Number	Percent	Number	Percent
Eye Care For Diabetic Patients				
Ophthalmologic examination				
Within 2 Years	632	63.0	685	50.0
>2 Years	108	11.0	170	12.0
Never saw ophthalmologist				
Optometric examination	172	17.0	456	33.0
No optometric examination	81	8.0	40	3.0
Questionable status	2	0	19	1.0
Eye Care For Persons With Proliferative Diabetic Retinopathy With DRS HRC*				
Ophthalmologic examination				
Within 2 Years	43	90.0	25	93.0
>2 Years	2	4.0	1	4.0
Never saw ophthalmologist				
Optometric examination	3	6.0	1	4.0
No optometric examination	0	0	0	0
Questionable status	0	0	0	0

*DRS HRC = Diabetic Retinopathy Study high risk characteristics for visual loss.

SOURCE: Witkin, SR, and R Klein. Ophthalmologic care for persons with diabetes. JAMA 251:2534-37, 1984.

TABLE 17. *Characteristics of diagnosis during ophthalmoscopic examination for proliferative diabetic retinopathy, by physician specialty*

	Percent Correctly Diagnosed as Having Proliferative Retinopathy* (Mean ± SD)	Percent Correctly Diagnosed as Not Having Proliferative Retinopathy** (Mean ± SD)	Predictive Value*** (Percent)	
			Positive	Negative
Internists, diabetologists, and senior medical residents	49 ± 5	84 ± 5	9	98
Ophthalmologists and retinal specialists	96 ± 2	93 ± 3	29	99

*Chi^2 = 32.69, P<.001.

**Chi^2 = 3.59, P = .057.

***The predictive value of the positive statement is the probability of physicians who say proliferative diabetic retinopathy is present when it is; the negative value is those who say it is not present when it is not. Assumes the prevalence of proliferative retinopathy to be 3 percent, which is an estimate of the actual prevalence of this diagnosis in diabetic patients.

SOURCE: Sussman, EJ, WG Tsiaras, and KA Soper. Diagnosis of diabetic eye disease. JAMA 247:3231-34, 1982.

Prevalence rates of reported photocoagulation in the WESDR are presented in Tables 18 and 19. In younger-onset patients, the rates of photocoagulation treatment increased with increasing current age and were higher in males than in females. In older-onset persons, the reported rate for the group was 3.8 percent.

TABLE 18. *History of photocoagulation treatment by sex in insulin-taking persons diagnosed prior to age 30 years examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

	Photocoagulation by History					
	Males			Females*		
Current Age (Years)	Number	No	Yes	Number	No	Yes
<15	61	100.0	0	52	100.0	0
15-44	384	83.3	16.7	362	87.6	12.2
45+	66	68.2	31.8	70	78.6	21.4
Total	511	83.4	16.6	484	87.6	12.2

*The history of photocoagulation was uncertain in 0.2 percent of females.

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

TABLE 19. *History of photocoagulation treatment in persons diagnosed at age 30 years or older examined in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (Wisconsin HSA-1, 1980-82)*

	Photocoagulation by History*		
Current Age (Years)	Number	No	Yes
30-44	49	98.1	1.9
45-64	519	94.4	5.1
65-84	738	96.6	2.8
85+	64	91.8	5.8
Total	1,370	95.6	3.8

*The history of photocoagulation treatment was uncertain in 0.6 percent of persons.

SOURCE: Klein, R. WESDR. Unpublished data, 1980-82.

ACKNOWLEDGMENT

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APPENDIX A. *Resource material for visually impaired diabetic persons*

Blindness and Diabetes. American Foundation for the Blind, Inc. Publications Division, 15 W. 16th Street, New York, NY 10011.

Diabetic control: Equipment for use with vision loss. Aids and Appliances Review, issue no. 6, June 1982. The Carroll Center for the Blind, 770 Centre Street, Newton, MA 02158, (617) 969-6200.

Diabetes Teaching Guide, by George P. Kozak, M.D. The Joslin Clinic, One Joslin Place, Boston, MA 02215, (617) 732-2539.

Materials and Aids for the Visually Impaired Diabetic. National Diabetes Information Clearinghouse, Box NDIC, Bethesda, MD 20205, (202) 842-7630.

Special Devices and Equipment for the Visually Impaired Diabetic. Prepared by Keith Campbell, American Pharmacy Association. Vision Foundation, Inc., 2 Mt. Auburn Street, Watertown, MA 02172, 1-800-852-3029 or 1-617-926-4232.

Teaching Guides for Diabetes Education Programs: Selected Annotations. National Diabetes Information Clearinghouse, Box NDIC, Bethesda, MD 20205 (202) 842-7630.

You, Your Eyes and Your Diabetes, by Donna L. Johnson. The Hadley School for the Blind, 700 Elm Street, Winnetka, IL 60093, 1-800-323-4238 or 1-800-942-4193 (Illinois residents).

Regional libraries for the blind and physically handicapped can be consulted for information, or contact the Library of Congress, Division for the Blind and Physically Handicapped, 1291 Taylor Street, N.W., Washington, DC 20542.

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APPENDIX B. *Relationship of various characteristics of the younger-onset population (age at diagnosis <30 years, insulin-taking) with either any retinopathy and diabetes for less than ten years or with proliferative retinopathy and diabetes for ten or more years, WESDR, 1980-82*

	Duration of Diabetes <10 Years					Duration of Diabetes ≥10 Years				
Risk Factor	Range	No.	% Any Retin.	Relative Risk	95% Confidence Interval	Range	No.	% Prolif. Retin.	Relative Risk	95% Confidence Interval
Sex										
Female		190	40.5	1			294	33.7		
Male		228	36.0	0.89	(0.70, 1.14)		283	42.4	1.26	(1.02, 1.55)
Age at diagnosis (years)										
0-9		117	23.1	1			195	38.5	1	
10-19		188	44.1	1.91	(1.32, 2.76)		236	39.4	1.02	(0.81, 1.30)
20-29		113	43.4	1.88	(1.27, 2.78)		146	34.9	0.91	(0.68, 1.20)
Glycosylated hemoglobin (%)										
<25th percentile	6.6-10.6	99	33.3	1		6.0-11.0	137	34.3	1	
≥75th percentile	14.6-22.6	101	50.5	1.52	(1.08, 2.13)	13.9-23.3	136	38.2	1.11	(0.81, 1.53)
Systolic blood pressure (mmHg)										
<25th percentile	78-106	99	36.4	1		84-115	144	22.2	1	
≥75th percentile	123-157	105	39.0	1.07	(0.75, 1.53)	143-221	144	63.9	2.88	(2.07, 4.00)
Diastolic blood pressure (mmHg)										
<25th percentile	42-69	110	28.2	1		43-73	148	29.1	1	
≥75th percentile	83-108	98	53.1	1.88	(1.32, 2.68)	89-117	153	56.9	1.96	(1.47, 2.60)
Body mass index (lb/in^2 x 100)										
<25th percentile	2.05-2.80	105	24.8	1		2.04-3.10	144	37.5	1	
≥75th percentile	3.48-7.32	104	51.0	2.06	(1.40, 3.02)	3.72-6.21	144	43.8	1.17	(0.88, 1.55)
Proteinuria										
Absent or trace		376	37.8	1			376	21.8	1	
Present		25	48.0	1.27	(0.83, 1.95)		170	66.5	3.05	(2.45, 3.80)
Smoking Status (Age ≥18)										
Never smoked		148	46.6	1			281	36.7	1	
Ex-smoker		31	51.6	1.11	(0.76, 1.62)		105	47.6	1.30	(1.01, 1.67)
Current smoker		64	56.2	1.21	(0.92, 1.59)		169	39.1	1.06	(0.84, 1.36)

SOURCE: Klein, R. Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR). Unpublished data, 1980-82.

APPENDIX C. *Relationship of various characteristics of the older-onset population (age at diagnosis ≥30 years) with the presence of retinopathy, by duration of diabetes, WESDR, 1980-1982*

	Diabetes Duration 0-4 Years					Diabetes Duration 5-14 Years					Diabetes Duration 15+ Years				
Risk Factor	Range	No.	% Ret.*	Relative Risk	95% C.I.**	Range	No.	% Ret.*	Relative Risk	95% C.I.**	Range	No.	% Ret.*	Relative Risk	95% C.I.**
Age at diagnosis (years)															
30-49		69	23.2	1			139	58.3	1			272	82.4	1	
50-69		206	29.1	1.25	(.78, 2.03)		314	49.4	.85	(.71, 1.01)		214	70.6	.86	(.77, .95)
70+		76	32.9	1.42	(.83, 2.42)		66	34.8	.60	(.42, .86)		9	55.6	.68	(.38, 1.21)
Glycosylated hemoglobin (%)															
<25th percentile	6.2-8.4	80	21.2	1		6.2-9.3	120	41.7	1		6.8-9.7	106	59.4	1	
≥75th percentile	11.8-23.6	84	41.7	1.97	(1.20, 3.22)	12.8-18.8	127	59.1	1.42	(1.10, 1.83)	13.2-19.2	105	87.6	1.48	(1.24, 1.75)
Systolic blood pressure (mmHg)															
<25th percentile	80-126	89	18.0	1		94-131	128	46.9	1		85-133	123	72.4	1	
≥75th percentile	155-237	89	43.8	2.43	(1.47, 4.02)	159-263	130	63.8	1.36	(1.09, 1.70)	167-236	123	82.9	1.14	(1.00, 1.31)
Proteinuria															
Absent or trace		304	26.3	1			422	45.3	1			372	75.0	1	
Present		37	43.2	1.64	(1.08, 2.49)		70	74.3	1.64	(1.38, 1.95)		87	88.5	1.18	(1.07, 1.30)
Current diabetes treatment															
None		36	16.7	1			16	25.0	1			6	50.0	1	
Insulin		93	39.8	2.38	(1.10, 5.15)		226	60.2	2.41	(1.02, 5.66)		354	84.5	1.69	(.76, 3.77)
Oral		144	28.5	1.71	(.79, 3.70)		206	47.1	1.88	(.80, 4.46)		116	56.9	1.14	(.50, 2.57)
Diet		78	21.8	1.30	(.56, 3.03)		71	31.0	1.24	(.50, 3.10)		19	63.2	1.26	(.53, 3.02)
Smoking status															
Never smoked		188	31.9	1			272	54.8	1			284	76.4	1	
Ex-smoker		107	28.0	.88	(.61, 1.27)		169	43.8	.80	(.65, .98)		150	80.0	1.05	(.94, 1.16)
Current smoker		56	19.6	.61	(.35, 1.09)		78	46.2	.84	(.65, 1.10)		61	70.5	.92	(.78, 1.10)

*Ret. = retinopathy.

**C.I. = Confidence interval.

SOURCE: Klein, R. Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR). Unpublished data, 1980-82.

CHAPTER XIV. KIDNEY DISEASES ASSOCIATED WITH DIABETES

William H. Herman, M.D., and Steven M. Teutsch, M.D., M.P.H.

SUMMARY

The kidneys of diabetic patients undergo many functional and morphologic changes prior to the clinical appearance of diabetic nephropathy, which is marked by the development of constant proteinuria. In insulin-dependent diabetes mellitus (IDDM), nephropathy follows a well-characterized and predictable course from onset of constant proteinuria to renal insufficiency or death. In people with IDDM and persistent proteinuria, which develops on the average at 14-19 years after onset of diabetes, azotemia occurs 4-5 years later and end-stage renal disease (ESRD) or death follow within a year. In patients with noninsulin-dependent diabetes (NIDDM), proteinuria occurs earlier after clinical diagnosis of diabetes, but does not generally herald progressive renal insufficiency.

Approximately 10 percent of people with diabetes have diabetic nephropathy. Its prevalence increases with increasing duration of diabetes, and IDDM is associated with a higher prevalence of nephropathy than NIDDM is. After 15 years of diabetes, approximately one-third of people with IDDM and one-fifth of people with NIDDM develop diabetic nephropathy. Hypertension, poor glycemic control, and cigarette smoking are associated with a higher prevalence of nephropathy.

Diabetes accounts for approximately one-fourth of new cases of ESRD in the United States. The incidence of diabetic ESRD is 18 per million population, and the prevalence is 34 per million. It is approximately 15 times more common in people with IDDM than in people with NIDDM, and it is about three times more common in blacks than in whites. Therapy for diabetic ESRD has improved markedly in recent years. For diabetic patients treated with dialysis and transplantation, 1-year survival rates are 75 percent and 82 percent, respectively. Complication rates and costs are higher for diabetic than for nondiabetic ESRD patients. Cardiovascular disease is the most common cause of death.

Bacteriuria appears to be more common among women with diabetes than among women in the general population, and pyelonephritis and papillary necrosis are more

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prevalent among people with diabetes. Diabetics, particularly those with preexisting renal insufficiency, are at increased risk for radiocontrast-induced renal failure.

PROTEINURIA

The first clinical sign of diabetic nephropathy is intermittent glomerular proteinuria. Normal or above-normal glomerular filtration rates (GFR) persist as protein excretion becomes continuous and the rate of protein excretion increases. Thereafter, GFR falls and renal function deteriorates. When other causes of proteinuria such as heart failure or urinary tract infection are shown to be absent, proteinuria in diabetics is almost always due to diabetic renal microvascular disease. Numerous studies have attempted to define the prevalence of proteinuria in diabetes, but a coherent account has been slow to emerge. In part, this has been due to variability in the populations studied, different methods used to detect urinary protein, and different criteria used to define it.

Population-Based Studies

Two studies have reported the prevalence of proteinuria in unselected diabetic populations. In a sample survey of the United States in 1976-80, a medical history of proteinuria was reported by about 14 percent of diabetics ages 20-74 years. The rate was highest among the youngest diabetics, where it was four times higher than persons with normal glucose tolerance, and declined with increasing age to a rate equal to that of nondiabetics (Table 1). Similar rates for diabetics were found in a 1979-80 survey in an 11-county area in southwestern Wisconsin (population 793,000), in which semi-quantitative determinations of urine protein were performed on 3,130 of 10,207 identified diabetics. All persons diagnosed as diabetic prior to age 30 who took insulin, and a sample of those diagnosed at 30 years or older stratified by age and duration of diabetes, were tested. Four to 34 percent of the former group and 11-19 percent of the latter group had greater than 30 mg of protein per dl urine (Table 2).

TABLE 1. *Percent of persons who report having been told by a physician that they had protein or albumin in their urine, United States, 1976-80*

	Age (Years)				
	20-74	20-44	45-54	55-64	65-74
Diagnosed diabetes	14	23	19	10	8
Undiagnosed diabetes*	11	0	18	13	10
Impaired glucose tolerance*	8	13	2	10	7
Normal glucose tolerance*	7	5	8	8	8

*National Diabetes Data Group criteria for 75 gm 2-hour OGTT.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

Patient Studies

Clinical patient studies of diabetic nephropathy have selection biases, since diabetic inpatients tend to be more ill than diabetic outpatients, and diabetic outpatients tend to be more ill than people with diabetes in the general population (Melton et al. 1984). Nevertheless, clinical series can provide estimates of the prevalence of diabetic nephropathy. Proteinuria has been found in 5-12 percent of randomly selected diabetic patients in clinical series (Table 3).

TABLE 2. *Prevalence of proteinuria greater than 30 mg/dl in a population-based survey of diabetic patients, Wisconsin, 1979-80*

Duration of Diabetes (Years)	Onset of Diabetes < Age 30 and Insulin-Taking		Onset of Diabetes > Age 30, Age-Stratified	
	Number	Percent	Number	Percent
0-4	6/162	3.7	38/343	11.1
5-9	19/239	8.0	-	-
5-14	61/406	15.0	70/492	14.2
10-14	42/167	25.2	-	-
15+	128/379	33.8	87/459	19.0
All	195/947	20.6	195/1,294	15.1

SOURCE: Klein, R. University of Wisconsin, Madison. Personal communication, 1983.

TABLE 3. *Prevalence of proteinuria in clinical diabetic patients*

Reference	Source	Year of Publication	Number of Diabetics	Age Range	Percent With Proteinuria
a	Inpatients, University Hospital, Oslo, Norway	1951	1,335	10-70+	10
b	Outpatients, Pennsylvania Hospital, Philadelphia, PA	1955	103	20-60+	8
c	Inpatients, Deaconess Hospital, Boston, MA	1957	394	<10-80+	10
d	Outpatients, University College Hospital, London, England	1958	1,100	10-80+	5
e	Outpatients, University Hospital, Cairo, Egypt	1960	391	6-80	12
f	Outpatients, University Hospital, Tokyo, Japan	1972	333	<29-60+	7
	Totals				
	Outpatients	-	1,927	-	7
	Inpatients	-	1,729	-	10
	Both	-	3,656	-	8

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DIABETIC GLOMERULOSCLEROSIS

At the time of onset of diabetes, the kidney is morphologically normal, but thickening of the glomerular basement membrane and deposition of basement membrane-like material in the mesangium have been detected 2-5 years after the onset of diabetes (Osterby 1974). Over time, characteristic nodular, diffuse, and exudative glomerular lesions can be recognized by light microscopy. However, even after many years of diabetes, light-microscopic changes may be minimal or even occasionally absent (Watkins et al. 1972). Even when histological changes of glomerulosclerosis are present, 60-70 percent of diabetics do not develop clinical features of diabetic nephropathy (Gellman et al. 1959, Mogensen et al. 1983).

Light-microscopic studies have provided disparate estimates of the prevalence of diabetic glomerular lesions. In autopsy and biopsy studies, diabetic glomerular lesions have been found in 8-75 percent of diabetic patients (Table 4). This wide range is not surprising in light of the lack of standardized methods and criteria, and the variability of the populations studied. When standard criteria were used, 23-36 percent of autopsied diabetics were found to have nodular glomerulosclerosis, 20-46 percent nodular or diffuse glomerulosclerosis, and 8-12 percent severe diabetic glomerulosclerosis, generally defined as having nodules affecting more than three-quarters of the glomeruli (Table 4). Biopsy studies showed a greater range in prevalence of nodular glomerulosclerosis (11-48 percent). This finding is not unexpected since biopsies sample only a few glomeruli and may miss nodular pathology. Biopsy studies have also found higher prevalence of nodular or diffuse and severe glomerulosclerosis, perhaps because patients were selected for biopsy because of clinical evidence of renal disease (Halverstadt et al. 1966).

RISK FACTORS FOR DIABETIC RENAL MICROVASCULAR DISEASE

When data from clinical and autopsy series are stratified by duration of diabetes, age, age at death, and type of diabetes, the patterns of prevalence of glomerulosclerosis and proteinuria are found to be similar.

Duration of Diabetes

Increased duration of diabetes is the most important factor associated with increased prevalence of proteinuria (Tables 2 and 5) and diabetic glomerulosclerosis (Table 6).

Type of Diabetes

Although end-stage renal disease is more prevalent in IDDM than in NIDDM (see below), the prevalences of proteinuria and diabetic glomerulosclerosis are similar in IDDM and NIDDM when rates are stratified by duration of diabetes (Tables 2, 7, and 8). The higher rates of proteinuria and diabetic glomerulosclerosis among some

TABLE 4. *Percent of diabetics with glomerulosclerosis reported in autopsy and biopsy series, by type of glomerular lesion*

Reference	Source	Year of Publication	Number of Diabetics Studied	Nodular Only %	Nodular or Diffuse %	"Severe" %
Autopsy Data						
a	Mayo Clinic, Rochester, MN	1947	313	-	20	-
b	Boston City Hospital	1952	387	26	-	-
c	University of Minnesota, Minneapolis	1953	1,465	-	26	-
d	Boston City Hospital	1955	375	-	37	-
e	Edinburgh University, Scotland	1955	120	-	46	12
f	Yale University, New Haven, CT	1956	137	27	-	9
g	Kings County Hospital, Brooklyn, NY	1961	525	-	-	8
h	Jewish Hospital, St. Louis, MO	1962	130	36	-	-
i	Jap. Soc. Path., Japan	1974	2,754	-	25	-
j	University of Wisconsin, Madison	1978	200	23	-	12
Biopsy Data						
k	University of Chicago	1959	53	48	75	8
l	NY Medical College	1963	51	25	51	20
m	Massachusetts General Hospital, Boston	1966	80	11	75	8

TABLE REFERENCES

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m. Halverstadt, DB, GW Leadbetter, Jr, and RA Field. Pyelonephritis in the diabetic. Correlation of open renal biopsies and bacteriologic studies. JAMA 195:827, 1966.

TABLE 5. *Prevalence of proteinuria in clinical diabetic patients, by duration of diabetes*

Duration of Diabetes (Years)	MacNeal (a)		El Mahallawy (b)		Miki (c)		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
0-4	1/42	2	16/261	6	13/246	5	30/549	5
5-9	1/22	5	11/86	13	6/63	10	18/171	11
10+	6/39	15	20/44	45	4/24	17	30/107	28
10-14	3/16	19	11/29	38	-	-	14/45	31
15-19	0/7	0	5/11	45	-	-	5/18	28
20+	3/16	19	4/4	100	-	-	7/20	35
Total	8/103	8	47/391	12	23/333	7	78/827	9

TABLE REFERENCES

a. MacNeal, PS, and J Rogers. Symposium on diabetes and obesity: Complications of diabetes mellitus. Med Clin North Am 39:1607, 1955.
b. El Mahallawy, MNE, and MS Sabour. Etiological factors in diabetic nephropathy. JAMA 173:1783, 1960.
c. Miki, E, T Kuzuya, T Ide, et al. Frequency, degree, and progression with time of proteinuria in diabetic patients. Lancet 1:922, 1972.

TABLE 6. *Number and percent of diabetics with glomerulosclerosis at autopsy, by duration of diabetes*

Diabetes Duration (Years)	Number	Percent
<10	164/870	19
10-20	113/285	40
>20	46/88	52
Total	323/1243	26

SOURCE: Bell, ET. Renal vascular disease in diabetes mellitus. Diabetes 2:376, 1953.

populations with IDDM may be due to longer duration of diabetes among IDDM patients than among NIDDM patients. Another reason may be selective mortality among those with NIDDM. Patients with NIDDM are more likely to have unrecognized diabetes for several years before it is diagnosed, which probably explains the high prevalence of proteinuria early after diagnosis of NIDDM (Table 7).

Age

The highest prevalence of proteinuria in a study based on medical history occurred in diabetics ages 20-44 years (Table 1). In a summary of three clinical studies, the prevalence of proteinuria showed a bimodal pattern, with a peak at age 20-39 and a

TABLE 7. *Prevalence of proteinuria in clinical diabetic patients, by duration and type of diabetes*

Duration of Diabetes (Years)	Percent of "Juvenile-Onset" Patients			Percent of "Adult-Onset" Patients	
	White[1] (a) (N = 1,072)	Knowles[2] (b) (N = 167)	Mogensen[3] (c) (N = 291)	Fabre[4] (d) (N = 510)	Mogensen[3] (c) (N = 791)
0-4	1	1	11	7	19
5-9	2	2	15	16	26
10-14	7	7	18	21	23
15-19	18	19	30	26	28
20-29	-	-	29	-	47
20-24	41	32	-	35	-
25-29	39	42	-	-	-
30-39	-	-	35	-	22
30-34	44	47	-	-	-
35-39	63	47	-	-	-
Total	-	-	20	16	24

[1] Qualitative proteinuria in juvenile-onset patients surviving more than 20 years.
[2] Qualitative proteinuria in juvenile-onset patients surviving more than 10 years.
[3] >30 mg protein/l in cross-section of diabetic patients diagnosed at <30 years.
[4] $\geq$500 mg protein/24 hrs in diabetic patients diagnosed at >40 years.

TABLE REFERENCES

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d. Fabre, J, LP Balant, and PG Dayer. The kidney in maturity-onset diabetes mellitus: A clinical study of 510 patients. Kidney Int 21:730, 1982.

TABLE 8. *Prevalence of glomerulosclerosis at autopsy in diabetics, by duration of diabetes and age at death*

Duration of Diabetes (Years)	Age 20-40 Years at Death		Age 40-90 Years at Death	
	Number	Percent	Number	Percent
<10	2/66	3	162/804	20
10-20	18/35	51	95/250	38
>20	7/7	100	39/81	48
Total	27/108	25	296/1,135	26

SOURCE: Bell, ET. Renal vascular disease in diabetes mellitus. Diabetes 2:376, 1953.

subsequent increase after age 50-60 years (Table 9). The prevalence of glomerulosclerosis may also have a peak at about ages 20-39 (Table 10). In studies that have used multivariate analysis to control for confounding variables such as duration of diabetes, increasing age has not been found to be associated with a higher prevalence of diabetic nephropathy (Rate et al. 1983, West et al. 1980).

TABLE 9. *Prevalence of proteinuria in clinical diabetic patients, by age*

Age (Years)	Bjerkelund (a)		MacNeal (b)		El Mahallawy (c)		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
10-20	4/149	3	-	-	0/10	0	4/159	3
20-30	28/197	14	0/1	0	2/31	6	30/229	13
30-40	18/188	10	0/5	0	9/81	11	27/274	10
40-50	6/158	4	1/8	12	14/130	11	21/296	7
50+	82/643	13	7/89	8	22/135	16	111/867	13
50-60	23/241	10	-	-	12/103	12	35/344	10
60-70	35/265	13	-	-	10/31	32	45/296	15
>70	24/137	18	-	-	0/1	0	24/138	17
Total	138/1,335	10	8/103	8	47/388	12	186/1,736	11

TABLE REFERENCES

a. Bjerkelund, CJ. Diabetic renal disease. Clinical studies of 1,335 diabetics treated in Med. Dept. A of University Hospital, Oslo 1930-1950. Acta Med Scand 139:133, 1951.
b. MacNeal, PS, and J Rogers. Symposium on diabetes and obesity: Complications of diabetes mellitus. Med Clin North Am 39:1607, 1955.
c. El Mahallawy, MN, and MS Sabour. Etiological factors in diabetic nephropathy. JAMA 173:1783, 1960.

TABLE 10. *Prevalence of glomerulosclerosis at autopsy in Japanese diabetics, by age at death*

Age at Death (Years)	Number	Percent
0-9	0/7	0
10-19	3/35	9
20-29	29/88	33
30-39	46/135	34
40-49	75/259	29
50-59	162/615	26
60-69	273/1,012	27
70+	113/603	19
Total	701/2,754	25

SOURCE: Goto, Y, SI Sato, and M Masuda. Causes of death in 3,151 diabetic autopsy cases. Tohoku J Exp Med 112:339, 1974.

Race

There appear to be racial differences in the prevalence of diabetic nephropathy, which has been found to be more prevalent among certain groups of Native Americans, particularly the Winnebagos and Omahas of Nebraska (Waring 1970) and among the Pimas of Arizona (Kamenetzky et al. 1974). Recent studies have found the incidence of ESRD due to diabetic nephropathy to be almost three times greater among blacks than among whites (see Table 15). Higher rates of hypertension may contribute to the excess prevalence of clinically diagnosed diabetic nephropathy among Native Americans and blacks (West 1974).

HLA

Although genetic factors may be important, there is no preponderance of any HLA type among diabetic patients with nephropathy (Barbosa 1981, Christy et al. 1981, Pitkanen et al. 1981, Standl et al. 1982).

Sex

Men and women are probably equally affected by diabetic nephropathy, although some studies have found slightly greater rates of diabetic nephropathy among men (Andersen et al. 1978, West et al. 1980). Medicare ESRD program incidence data have found the incidence of ESRD due to diabetic nephropathy to be slightly higher in men (see Table 15), but part of the observed difference may be due to selection biases (Eggers et al. 1984).

Hypertension

Hypertension is associated with a higher prevalence of diabetic nephropathy. In prospective studies, hypertension has been shown to accelerate the progression of nephropathy, and antihypertensive treatment has reduced the rate of progression. In a prospective study of seven young male diabetic patients with constant proteinuria, a positive correlation between lower diastolic blood pressure and the rate of fall of GFR was demonstrated (Mogensen 1976). In a study of six patients, antihypertensive treatment reduced albumin clearance as a percent of GFR and reduced the rate of fall of GFR by more than 50 percent (Mogensen 1980). Other studies confirm these findings (Parving et al. 1983).

Glycemic Control

A number of recent, small prospective studies support the hypothesis that better glycemic control is associated with a lower incidence of diabetic nephropathy. In seven IDDMs of long duration, short-term intensive glycemic control reduced urinary albumin excretion (Viberti et al. 1979). In a 2-year prospective randomized study of 74 IDDMs with background retinopathy, intensive glycemic control with continuous subcutaneous insulin infusion resulted in significantly less deterioration in creatinine clearance than with conventional therapy (Holman et al. 1983). A Japanese study based on serial renal biopsies in 23 patients showed a more rapid development and progression of glomerular lesions in poorly controlled patients (Takazakura et al. 1975).

Cigarette Smoking

Cigarette smoking may contribute to nephropathy in patients with IDDM (Nielsen and Hjollund 1978). In one study this association persisted even after controlling for duration of diabetes (Christiansen 1978). However, other studies have not found an association between smoking and nephropathy (West et al. 1980).

THE COURSE OF DIABETIC NEPHROPATHY AND ESRD

IDDM

In IDDM, nephropathy follows a well-characterized course from the onset of diabetes, to the onset of persistent proteinuria, to renal insufficiency or death. In patients with IDDM who develop diabetic nephropathy, persistent proteinuria occurs on the average at 14-19 years after the onset of diabetes. Once persistent proteinuria has developed, azotemia (serum creatinine level greater than 5 mg/dl) develops in 4-5 years; end-stage renal disease or death follow within 6 months to a year (Table 11). These data are for mean duration of diabetes; thus half of IDDM patients have shorter rates of decline of renal function and half have longer rates. Decline of glomerular filtration rate may vary from individual to individual, but once constant proteinuria develops in patients with IDDM, GFR declines linearly with time at a rate of about 1 ml/min/month (Mogensen 1976; Viberti et al. 1983). The inverse of serum creatinine also shows a linear relationship with time, which follows a consistent course in any given individual (Jones et al. 1979).

NIDDM

The course of diabetic nephropathy is less well characterized in NIDDM patients, but it appears to be different. In persons diagnosed as diabetic at older ages, proteinuria occurs after shorter duration of diabetes than in IDDM patients. This probably reflects the longer period of unrecognized hyperglycemia that precedes the diagnosis of NIDDM (O'Sullivan et al. 1961). Proteinuria in NIDDM does not generally herald progressive renal insufficiency. Most patients with NIDDM and proteinuria maintain adequate glomerular filtration, and in one study, only 13 percent of NIDDM patients with proteinuria had progressive azotemia (Fabre et al. 1982). When progressive renal insufficiency does occur in NIDDMs, the time between onset of persistent proteinuria and development of end-stage renal disease appears to be similar to that observed in IDDM patients (Table 11).

DIABETIC END-STAGE RENAL DISEASE

In 1972, the Medicare End-Stage Renal Disease Program was created, which has made Federal support for dialysis and transplantation available to virtually all patients. An unknown, but probably small, number of patients with ESRD are not treated for ESRD because of age, misdiagnosis, or poor prognosis, and 7 percent of ESRD patients are not covered by the program (Eggers et al. 1984). Virtually all (91 percent) patients developing ESRD are treated initially with dialysis (Krakauer et al. 1983). Thus, the number of patients beginning dialysis each year and the number of patients receiving benefits through the Medicare ESRD program provide estimates of the incidence of ESRD in the United States and the incidence of ESRD due to diabetic nephropathy.

TABLE 11. *Mean duration of diabetes at onset of established proteinuria and end-stage renal disease (ESRD) or death*

Reference	Source	Number of Diabetics	Mean Years of Diabetes at Onset of:		
			Proteinuria	Creatinine >5 mg/dl	ESRD Therapy or Death
	"Juvenile-Onset" Diabetics				
a	Steno Hospital, Gentofte, Denmark	157	18.9	23.8	24.5
b	Joslin Clinic, Boston, MA	112	17.3	21.6	22.1
c	USC Medical Center, Los Angeles, CA	15	15.5	-	18.3
d	Deaconess Hospital, Boston, MA	13	13.9	-	18.8
e	Northwestern Hospital, Chicago, IL	8	-	-	18.5
f	Univ. of Washington, Seattle, WA	20	-	-	24.0
g	Univ. of Minnesota, Minneapolis, MN	220	-	-	20.6
h	Scandinavia	146	-	-	22.7
i	Mayo Clinic, Rochester, MN	37	-	-	22.0
j	Nebraska	36	16.1	-	17.9
	"Adult-Onset" Diabetics				
c	USC Medical Center, Los Angeles, CA	135	12.8	-	15.9
e	Northwestern Hospital, Chicago, IL	6	-	-	13.8
j	Nebraska	27	10.1	-	11.9

TABLE REFERENCES

a. Andersen, AR, JK Andersen, JS Christiansen, et al. Prognosis for juvenile diabetics with nephropathy and failing renal function. Acta Med Scand 203:131, 1978.
b. Kussman, MJ, H Goldstein, and RE Gleason. The clinical course of diabetic nephropathy. JAMA 236:1861, 1976.
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d. Wilson, JL, HF Root, and A Marble. Diabetic nephropathy: Clinical syndrome. New Engl J Med 245:513, 1951.
e. Huang, C, FD Greco, P Ivanovich, et al. Maintenance dialysis for diabetic nephropathy with uremia. J Chronic Dis 28:365, 1975.
f. Blagg, CR. Visual and vascular problems in dialyzed diabetic patients. Kidney Int 6 (Suppl 1):27, 1974.
g. Rao, KV, D Sutherland, CM Kjellstrand, et al. Comparative results between dialysis and transplantation in diabetic patients. Trans Am Soc Artif Intern Organs 23:427, 1977.
h. Joint Scandinavian Report. Renal transplantation in insulin-dependent diabetics. Lancet 2:915, 1978.
i. Zincke, H, JE Woods, PJ Palumbo, et al. Renal transplantation in patients with insulin-dependent diabetes mellitus. JAMA 237:1101, 1977.
j. Rettig, B, and SM Teutsch. The incidence of end-stage renal disease in Type I and Type II diabetes mellitus. Diabetic Nephropathy 3:26, 1984.

Incidence

In 1980, the incidence (new cases per year) of ESRD due to all causes was 82 per million population in the United States. Patient history forms on which the cause of ESRD is listed were completed for only about half (9,310/18,279) of new ESRD patients. However, by extrapolating from the number of incident cases due to diabetes in those patients for whom the forms were completed, it is estimated that the incidence of ESRD due to diabetic nephropathy was 18 per million population. Diabetes thus accounted for 22 percent of new cases of ESRD in the United States (Table 12).

TABLE 12. *Incidence of end-stage renal disease (ESRD) and of ESRD due to diabetic nephropathy*

Reference	Location	Year of Study	Percent of All New ESRD Cases Due to Diabetes	Number of New Cases of ESRD Due to: All Causes	Number of New Cases of ESRD Due to: Diabetes	New Cases Per Million Population Due to: All Causes	New Cases Per Million Population Due to: Diabetes
a	Brooklyn, NY	1980	26	346	90	123	32
b	Missouri Kidney Program	1981	27	436	118	88	24
c	ESRD Network #8, Nebraska & Iowa	1981	35	306	107	66	23
d	ESRD Network #5, Colorado, Utah, & Wyoming	1982	25	326	81	56	14
e	Medicare, United States*	1980	22	18,279	4,001	82	18
		1979	19	17,243	3,224	78	15
		1978	18	15,584	2,805	71	13

*Data on diabetes extrapolated to the total number of incident cases from the one-half of cases for which patient history forms were completed.

TABLE REFERENCES

a. Rao, TKS, and EA Friedman. Diabetic nephropathy in Brooklyn. In: Friedman, EA, and FA L'Esperance, Jr, eds. Diabetic Renal-Retinal Syndrome. Vol. 2. New York: Grune and Stratton, 1982. p. 3.
b. Missouri Kidney Program; 406 Turner Avenue, Columbia, MO.
c. ESRD Network #8; 8611 Hickman Road, Des Moines, IA.
d. ESRD Network #5; 1390 Logan Street, Denver, CO.
e. Eggers, PW, R Connerton, and H McMullan. The Medicare experience with end-stage renal disease. Health Care Financing Review, March 1984.

In four individual localities, the proportion due to diabetes was higher, ranging from 25 percent to 35 percent (Table 12). The percent of new patients with ESRD due to diabetes in the United States has tripled since the program was instituted in 1973 (Table 13). This increase probably reflects a growing tendency to accept patients with systemic diseases into dialysis programs in the United States.

Diabetic nephropathy is the most common cause of renal failure in persons ages 25-64 years (Table 14). The highest incidence rates per million population occurred in persons ages 55-64 years, although the highest estimated rates per million diabetics

TABLE 13. *Trends by year in the percent of new end-stage renal disease (ESRD) patients and the percent of prevalent ESRD patients with primary diagnosis of diabetic nephropathy*

Reference	Location	1973	1974	1975	1976	1977	1978	1979	1980	1981
	Incident cases									
a	Brooklyn, N.Y.	7	13	14	25	23	26	25	26	-
b	Michigan	-	12	14	11	14	16	21	23	25
c	Medicare, U.S.*	7	12	12	14	16	18	19	22	-
	Prevalent cases									
c	Medicare, U.S.*	-	7.7	8.2	8.6	9.6	10.3	10.4	10.5	11.8

*Data based on cases for which the cause of ESRD was reported, which was about one-half of all incident cases.

TABLE REFERENCES

a. Rao, TKS, and EA Friedman. Diabetic nephropathy in Brooklyn. In: Friedman, EA, and FA L'Esperance, Jr, eds. Diabetic Renal-Retinal Syndrome. Vol. 2. New York: Grune & Stratton, 1982.
b. Weller, JM, HWW Shu-Chen, CW Ferguson, and VM Hawthorne. Am J Nephrology 5:84-95, 1985.
c. Eggers, PW, R Connerton, and M McMullan. The Medicare experience with end-stage renal disease: Trends in incidence, prevalence, and survival. Health Care Financing Review, March 1984.

TABLE 14. *Percent distribution by age group of causes of new cases of end-stage renal disease (ESRD), United States, 1980**

Diagnosis	All Ages	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75+
Diabetic nephropathy	21.8	0.7	5.5	30.8	28.1	24.3	25.9	17.4	10.4
Glomerulonephritis	19.7	37.2	40.0	30.7	24.0	17.6	15.2	14.6	12.6
Primary hypertensive disease	23.4	0.0	5.9	11.9	20.0	24.4	25.0	29.1	36.7
Polycystic kidney disease	5.9	6.6	1.1	2.3	7.5	10.7	7.4	4.5	2.0
Collagen vascular disease	1.4	2.2	4.7	2.5	2.1	1.4	0.6	0.8	0.4
Interstitial nephritis, hereditary	1.0	2.9	4.4	2.2	0.9	0.5	0.7	0.3	0.4
Interstitial nephritis, other	6.4	4.4	8.1	5.1	4.1	5.6	6.6	7.1	9.3
Obstructive uropathy, acquired	2.4	0.7	1.1	0.7	0.4	1.4	2.4	4.2	5.8
Obstructive uropathy, congenital	1.1	18.2	9.1	2.0	0.6	0.1	0.1	0.1	0.0
Other causes	8.1	21.1	13.5	6.7	5.9	6.7	8.5	17.3	7.7
Etiology unknown	8.8	5.8	6.6	5.2	6.5	7.2	7.7	4.4	14.6

*Data based on cases for which the cause of ESRD was reported, which was about one-half of all incident cases.

SOURCE: Eggers, PW, R Connerton, and M McMullan. The Medicare experience with end-stage renal disease. Health Care Financing Review, March 1984.

occurred in persons ages 15-44 years (Table 15). ESRD due to diabetic nephropathy was slightly more common among men than among women, and was approximately three times more common among blacks than among whites (Table 15). This race differential is supported by data on race-specific incidence rates of ESRD due to diabetes from southeastern Michigan for the years 1973-1975 and from Jefferson

County, Alabama for the years 1974-1978. The relative risk for ESRD due to diabetes was 3.3 for blacks versus whites in Michigan and 3.4 for blacks versus whites in Alabama (Easterling 1977, Rostand et al. 1982). Incidence in the diabetic population was estimated at 731 per million diabetics in 1980; the highest rate occurred in the 15-44 year age group (Table 15).

TABLE 15. *Incidence of end-stage renal disease (ESRD) due to diabetic nephropathy, United States, 1980**

Rate Per Million Population				Rate Per Million Diabetics	
Age (Years)	Incidence	Sex and Race	Incidence	Age (Years)	Incidence
0-14	<1	Male	19	<15	37
15-24	1	Female	17	15-44	1,568
25-34	18	White	14	45-64	729
35-44	24	Black	40	65+	400
45-54	33			All ages	731
55-64	53				
65-74	42				
75+	16				
All ages	18				

*Data based on cases for which the cause of ESRD was reported, which was about one-half of all incident cases.

SOURCE: Eggers, PW, R Connerton, and M McMullan. The Medicare experience with end-stage renal disease. Health Care Financing Review, March 1984.

Incidence in IDDM and NIDDM Patients

The incidence of ESRD in patients with IDDM or NIDDM has been determined only for Nebraska for the years 1979-1981. The annual incidence was 410.5 per 100,000 persons with IDDM; the rate for persons with NIDDM was 26.4 per 100,000, which was only 6 percent of the rate for IDDM (Rettig and Teutsch 1984).

Prevalence

In 1981, the prevalence of ESRD due to diabetic nephropathy in the United States was 7,560 patients (34 per million population), and the prevalence of ESRD due to all causes was 64,063 patients (286 per million) (Eggers et al. 1984). Diabetes thus accounted for 11.8 percent of prevalent cases of ESRD in the United States, which was only about half of its representation in incident cases (Table 13). This lower proportion reflects the poorer survival rate of persons with ESRD due to diabetic nephropathy versus patients with ESRD due to other causes and their consequent more rapid loss from the prevalent population of ESRD patients. The prevalence of ESRD due to diabetes has increased by only about 50 percent since 1974 (Table 13), in contrast to the doubling of incident cases due to diabetes.

THERAPY AND COMPLICATIONS IN DIABETIC ESRD PATIENTS

In 1982, approximately 19,000 Americans began hemodialysis for ESRD, 2,000 began peritoneal dialysis, and 5,300 received kidney transplants (Table 16). About 60,000 patients received maintenance hemodialysis treatment and 6,500 received maintenance peritoneal dialysis. Among patients with ESRD due to diabetic nephropathy, 5,130 began hemodialysis, 500 began peritoneal dialysis, and 930 received kidney transplants. Approximately 7,300 diabetic patients received maintenance hemodialysis treatment and 820 received maintenance peritoneal dialysis (Table 16).

TABLE 16. *End-stage renal disease (ESRD): Estimated incident cases, prevalent cases, and annual cost, United States, 1982*

	ESRD--All Cases			ESRD--Diabetic Nephropathy		
	Incident Cases	Prevalent Cases	Medicare Cost ($ Billions)	Incident Cases	Prevalent Cases	Medicare Cost ($ Billions)
Hemodialysis	19,000	60,000	1.43	5,130	7,300	0.26
Peritoneal dialysis	2,000	6,500	0.15	500	820	0.03
Transplantation	5,300	-	0.17	930	-	0.04
Total	-	-	1.75	-	-	0.33

SOURCES: Eggers, PW, R Connerton, and M McMullan. The Medicare experience with end-stage renal disease: Trends in incidence, prevalence, and survival. Health Care Financing Review, March 1984. Vollmer, WM, PW Wahl, and CR Blagg. Survival with dialysis and transplantation in patients with end-stage renal disease. N Engl J Med 308:1553, 1983.

Retinopathy and Blindness

Approximately 97 percent of newly evaluated uremic diabetic patients have significant retinopathy (Blagg 1974) and over one-quarter are blind (Andersen et al. 1978, Goldstein and Massry 1978). However, the rate of visual loss in hemodialysis-treated diabetic patients has improved dramatically in recent years. Between 1966 and 1971, 44 percent of IDDM patients receiving hemodialysis in Minneapolis became blind while on treatment. Between 1972 and 1975, only 20 percent became blind, and, since 1976, only 4 percent have become blind while on hemodialysis (Shapiro and Comty 1982). This improvement primarily reflects more timely ophthalmologic intervention and greater attention to blood pressure control.

Infections

Rates of peritonitis are not excessive among diabetic patients on chronic ambulatory peritoneal dialysis (CAPD), but peritonitis remains a significant problem for both diabetic and nondiabetic patients on CAPD (Table 17). Among all patients on CAPD, peritonitis develops approximately once a year, and they are hospitalized approximately 1 day per month for peritonitis. Diabetic CAPD patients also develop peritonitis about once a year, but they spend approximately 3 days per month in the hospital (Table 17). Hospitalization rates for peritonitis are similar for patients with IDDM and NIDDM (Khanna et al. 1983).

Infection appears to be a particular problem among diabetic renal transplant recipients. Fifteen and 14 percent of diabetic renal transplant recipients at two centers had surgical wound infections, as compared to only 2 percent of nondiabetic transplant patients (Table 18).

TABLE 17. *Peritonitis and survival among diabetic and nondiabetic chronic ambulatory peritoneal dialysis (CAPD) patients*

Reference	Location	Number and Type of Patients	Total Months on CAPD	Mean Duration (Months) Between Episodes of Peritonitis	Days of Hospitalization Per Patient Per Month For: Peritonitis	Days of Hospitalization Per Patient Per Month For: All Causes	Percent 1-Year Survival on CAPD
a	University of Wisconsin	14 Diabetics	126	3.5	1.0	3.3	70
	Madison, WI	27 Nondiabetics	269	3.7	1.4	3.4	92
b	Mayo Clinic Rochester, MN	29 Diabetics	400	8	-	2.6	78
		40 Nondiabetics	600	8	-	2.0	98
c	Paris, France	24 Diabetics	256	11.6	-	-	84
d	Toronto,Canada	37 Diabetics	589	20.3	1.3	2.8	87

TABLE REFERENCES

a. Madden, MA, SW Zimmerman, and DP Simpson. Continuous ambulatory peritoneal dialysis in diabetes mellitus. The risks and benefits of intraperitoneal insulin. Am J Nephrol 2:133, 1982.

b. Kurtz, SB, VH Wong, CF Anderson, et al. Continuous ambulatory peritoneal dialysis. Three years' experience at the Mayo Clinic. Mayo Clin Proc 58:633, 1983.

c. Rottembourg, J, YE el Shahat, A Agrafiotis, et al. Continuous ambulatory peritoneal dialysis in insulin-dependent diabetic patients: A 40-month experience. Kidney Int 23:40, 1983.

d. Khanna, R, G Wu, L Chisholm, and G Oreopoulos. Update: Further experience with CAPD in diabetics with end-stage renal disease. Diabetic Nephropathy 2:8, 1983.

TABLE 18. *Infections and amputations among renal transplant patients*

Reference	Location	Number and Type of Patients	Number (Percent) of Infections	Number (Percent) of Amputations
a	Mayo Clinic, Rochester, MN	61 Diabetics	9 (15)*	-
b	Downstate Medical Center, Brooklyn, NY	57 Diabetics	8 (14)	19 (33)
		57 Nondiabetics	1 (2)	-
c	Mayo Clinic, Rochester, MN	101 Diabetics	-	23 (23)
d	Scandinavia	146 Diabetics	-	18 (12)
e	Hennepin Co. Medical Center, Minneapolis, MN	305 Diabetics	-	45 (15)
		202 Nondiabetics on dialysis	-	10 (5)

*7 of these patients died.

TABLE REFERENCES

a. Zincke, H, JE Woods, SS Sterioff, et al. Renal transplantation in patients with diabetes mellitus--revisited. Transplant Proc 11:55, 1979.

b. Butt, KMH, GA Arshad, M Chaudhury, et al. Total surgical care in uremic diabetes. In: Friedman, EA, and FA L'Esperance, Jr, eds. Diabetic Renal-Retinal Syndrome. Vol. 2. New York: Grune & Stratton, 1982. p. 361.

c. Okiye, SE, DE Engen, SS Sterioff, et al. Primary and secondary renal transplantation in diabetic patients. JAMA 249:492, 1983.

d. Joint Scandinavian Report. Renal transplantation in insulin-dependent diabetics. Lancet 2:915, 1978.

e. Kjellstrand, CM, CM Comty, and FL Shapiro. A comparison of dialysis and transplantation in insulin-dependent diabetic patients. In: Friedman, EA, and FA L'Esperance, Jr, eds. Diabetic Renal-Retinal Syndrome. Vol. 2. New York: Grune & Stratton, 1982. p. 405.

Amputations

The rate of amputations appears to be excessively high among diabetic renal transplant patients (Table 18). However, since transplant patients who have amputations generally have them more than 2 years after transplantation, amputees may represent a selected group of transplant patients who survive long enough to require amputations (Sutherland et al. 1982). It is also possible that diabetic vascular disease and immunosuppressive therapy contribute to the higher rate of amputations.

Cardiovascular Disease

Approximately one-third of uremic diabetic patients have angina pectoris (Kassissieh et al. 1974) and approximately one-fifth have had myocardial infarctions (Goldstein and Massry 1978, Mitchell et al. 1978). Cardiac arteriography performed prior to ESRD therapy in uremic IDDM patients without clinical evidence of coronary artery disease revealed a 42-54 percent prevalence of significant coronary artery disease (greater than 50 percent stenosis) (Bennett et al. 1978, Weinrauch et al. 1978), and critical coronary stenosis is probably even more prevalent in uremic patients with NIDDM.

SURVIVAL OF DIABETIC ESRD PATIENTS

Comprehensive survival data for patients begun on hemodialysis between January 1977 and December 1980 have recently been reported for all patients in the United States receiving benefits under the end-stage renal disease program. Of 5,856 dialysis patients with diabetic nephropathy, 75 percent survived for 1 year and 39 percent survived for 3 years. Higher rates occurred for all dialysis patients: 81 percent of 65,270 patients survived for 1 year and 56 percent survived for 3 years (Krakauer et al. 1983). In Minneapolis, IDDMs under age 61 undergoing hemodialysis had a 1-year survival of 84.4 percent and a 3-year survival of 60.8 percent (Shapiro and Compty 1982). Death rates among NIDDM hemodialysis patients were similar to those of IDDM patients under age 61 and to rates for nondiabetics over age 61 (Table 19).

TABLE 19. *Death rates per 1,000 hemodialysis treatment months, by age and year of initiation of treatment*

Diabetes Type and Year of Treatment	Age at Death (Years)	Number of Deaths	Death Rate Per 1,000 Treatment Months
IDDM			
1966-71	<61 (mean 37.2)	23	36.2
1972-75	<61 (mean 38.4)	46	27.3
1976-81	<61 (mean 37.2)	98	14.5
1976-81	61+ (mean 67.0)	16	41.0
NIDDM			
1972-75	Mean 58.6	18	28.3
1976-81	Mean 62.9	74	16.6
Nondiabetics			
1966-71	<61 (mean 40.8)	197	15.0
1972-75	<61 (mean 43.0)	190	9.0
1976-81	<61 (mean 39.9)	280	6.0
1976-81	61+ (mean 69.5)	212	15.4

SOURCE: Shapiro, FL, and CM Comty. Hemodialysis in diabetics--1981 update. In: Friedman, EA, and FA L'Esperance, Jr, eds. Diabetic Renal-Retinal Syndrome. Vol. 2. New York: Grune & Stratton, 1982. p. 309.

Preliminary results indicate that chronic ambulatory peritoneal dialysis (CAPD) is effective in diabetic patients and that survival is good, although mortality is higher in diabetic CAPD patients than in nondiabetic CAPD patients (Table 17). One study found a 100 percent 1-year survival and an 89 percent 3-year actuarial survival in 16 IDDM patients treated with CAPD, and a 90 percent 1-year survival and a 50 percent 3-year actuarial survival among 32 NIDDM patients on CAPD (Mion 1981). Another study found a 62 percent 4-year survival rate for 29 patients with IDDM using CAPD and a 27 percent 4-year survival rate for 8 patients with NIDDM (Khanna et al. 1983).

Since 1979, survival rates for patients and their donated kidneys have been similar for diabetic and nondiabetic recipients in all donor source categories in Minnesota (Table 20). However, the United States experience between 1977 and 1980 showed poorer patient and kidney survival rates than those reported from Minnesota. Patient survival rates were lower for patients with ESRD due to diabetes than for patients with ESRD due to other causes, but donated kidney survival rates were comparable for patients with ESRD due to diabetes and for those with ESRD due to other causes (Table 21).

One small study reported survival rates for diabetic ESRD patients who received transplants between 1972 and 1978 according to type of diabetes. Three juvenile-onset diabetic patients (mean age 30 years), who had living related renal transplants had a 100 percent 4-year survival, and 10 receiving cadaveric transplants had a 57 percent 4-year survival. Among 11 adult-onset diabetic patients (mean age 62 years) receiving cadaveric transplants, 5 percent survived for 4 years (Dumler et al. 1979).

TABLE 20. *Two-year patient and donated kidney survival in renal allograft recipients, by donor source, University of Minnesota, 1979-81*

	Related Donor				Cadaver	
	HLA Identical		HLA Nonidentical			
	Number	Percent	Number	Percent	Number	Percent
Patient survival for 2 years						
Diabetics	29	100	44	91	51	75
Nondiabetics	34	94	61	90	65	91
Kidney survival for 2 years						
Diabetics	29	100	44	87	51	62
Nondiabetics	34	91	61	77	65	77

SOURCE: Sutherland, DE, CE Morrow, DS Fryd, et al. Improved patient and primary renal allograft survival in uremic diabetic recipients. Transplantation 34:319, 1982.

MORTALITY FROM DIABETIC KIDNEY DISEASE

Clinical Studies

Renal failure is an important cause of death among diabetic patients. In an autopsy study of 1,465 diabetic patients, renal disease accounted for 8 percent of deaths (Bell 1953). Another study found that renal failure accounted for 10 percent of 1,854 deaths of autopsied diabetics (Warren et al. 1966).

TABLE 21. *One- and three-year patient and donated kidney survival, by primary disease and donor source, United States, 1977-80*

	Related Donor			Unrelated Donor		
Primary Disease	Number of Patients	1-Year Survival (Percent)	3-Year Survival (Percent)	Number of Patients	1-Year Survival (Percent)	3-Year Survival (Percent)
Patient Survival						
Diabetic nephropathy	268	89	82	518	79	65
Hypertension	159	93	86	593	85	77
Polycystic kidney disease	75	91	82	293	81	77
Glomerulonephritis	811	97	93	1,760	87	81
Kidney Survival						
Diabetic nephropathy	268	69	59	518	50	39
Hypertension	159	65	59	593	52	37
Polycystic kidney disease	75	68	60	292	50	43
Glomerulonephritis	809	76	67	1,758	55	45

SOURCE: Krakauer, H, JS Grauman, MR McMullan, and CC Creede. The recent U.S. experience in the treatment of end-stage renal disease by dialysis and transplantation. N Engl J Med 308:1558, 1983.

In one clinical study, renal disease caused death in 35 percent of patients with diabetes diagnosed before age 40, but only 12 percent of those diagnosed after age 40 years (Lundbaek 1965). Renal disease accounted for 9 percent of all deaths among 6,800 Joslin Clinic patients with diabetes who died between 1956 and 1965, but accounted for 42 percent of deaths in patients diagnosed at less than age 20 and only 6 percent of deaths in patients diagnosed over age 20 years (Balodimos 1971). In a Japanese study of the prevalence of renal failure as cause of death among diabetic autopsy cases that had pathologic evidence of diabetic glomerulosclerosis, renal failure was a more common cause of death among younger patients than among older diabetics (Table 22). The lower mortality due to ESRD in older patients with diabetic glomerulosclerosis was undoubtedly due in part to differences in the natural history of diabetic nephropathy in older- and younger-onset patients. It was also probably due to selective survival, since the population with later onset of diabetes is at greater risk of death from macrovascular disease.

ESRD Patient Studies

The death rate from ESRD in IDDM patients is significantly higher than among NIDDM patients and nondiabetics. Among young IDDM patients on hemodialysis, the death rate was two to three times higher than among nondiabetic hemodialysis patients of similar age in each of three study periods (Table 19). Among older IDDMs, the death rate was 2.5 times the rate of NIDDMs and nondiabetics of similar mean age. In contrast, the death rate of NIDDM patients was almost equal to that of age-matched nondiabetics during 1976-81 (Table 19).

Cardiovascular disease is the most common cause of death among diabetic hemodialysis patients. Cardiac and cerebrovascular events accounted for 61.5 percent of deaths among diabetic hemodialysis patients reported from Minneapolis (Table 23). These

TABLE 22. *Prevalence of renal failure as cause of death among Japanese diabetic autopsy cases with diabetic glomerulosclerosis*

Age at Death (Years)	Number With Diabetic Glomerulosclerosis	Number Dying With Renal Failure	Percent Due to Renal Failure
0-19	3	0	0.0
20-39	75	71	94.7
40-59	237	209	88.2
60-79	375	245	65.3
80+	11	6	54.5
Total	701	531	75.8

SOURCE: Goto, Y, SI Sato, and M Masuda. Causes of death in 3,151 autopsy cases. Tohoku J Exp Med 112:339, 1974.

TABLE 23. *Percent of deaths due to certain causes in diabetic hemodialysis and renal transplant patients*

Reference		Cardiovascular	Uremia	Infection	Other
	Hemodialysis Patients				
	Minneapolis				
a	<18 months of dialysis	75.0	9.5	3.6	11.9
a	>18 months of dialysis	39.2	27.5	19.6	13.7
	Total	61.5	16.3	9.6	12.6
b	Europe	72	-	-	-
	Renal Transplant Patients				
b	Europe	44	2	46	9
c,d,e	United States and Scandinavia	38	7	35	20

TABLE REFERENCES

a. Shapiro, FL, and CM Comty. Hemodialysis in diabetics--1981 update. In: Friedman, EA, and FA L'Esperance, Jr, eds. Diabetic Renal-Retinal Syndrome. Vol. 2. New York: Grune & Stratton, 1982. p. 309.
b. Jacobs, C, M Broyer, FP Brunner, et al. Combined report on regular dialysis and transplantation in Europe, 1980. In: Robinson, BHB, ed. Proceedings of the European Dialysis and Transplant Association. Vol. 18. London: Pitman Books Ltd., 1981.
c. Najarian, JS, DE Sutherland, RL Simmons, et al. Ten-year experience with renal transplantation in juvenile-onset diabetics. Ann Surg 190:487, 1979.
d. Okiye, SE, DE Engen, SS Sterioff, et al. Primary and secondary renal transplantation in diabetic patients. JAMA 249:492, 1983.
e. Joint Scandinavian Report. Renal transplantation in insulin-dependent diabetics. Lancet 2:915, 1978.

were common causes of early deaths (less than 18 months after onset of dialysis), while uremia was a more common cause of late deaths (more than 18 months after beginning dialysis). The European Dialysis and Transplantation Association has reported that 72 percent of deaths among hemodialysis patients were due to cardiovascular disease. In addition, the association reported on 94 deaths that occurred among diabetic first renal transplant recipients. While 44 percent were due to cardiovascular disease, 46 percent were due to infections; uremia and other conditions were minor causes (Table 23). Other reports showed 217 deaths among diabetic patients who received renal transplants since 1968 at eight Scandinavian centers (n = 79) and two United States centers (n = 138). Similarly to the association results, 38 percent died of cardiovascular disease, 35 percent died of infection, 7 percent died of uremia, and 20 percent died of other causes (Table 23).

Death Certificate Studies

In 1979, 128,373 death certificates of residents of the United States mentioned diabetes as a cause of death, and 9,468 (7.4 percent) of them also indicated the presence of kidney disease (Table 24). A higher proportion of deaths due to renal disease occurs among younger diabetic patients than among older diabetics. In 1979, for death certificates listing diabetes, renal disease was mentioned in 18.8 percent of deaths occurring at less than 45 years of age and in 7.1 percent of those occurring at 45 years and over (Table 24). The highest rate was for persons ages 25-34 years, where 27.5 percent of death certificates listed renal disease. The relative risk of dying from renal disease was 1.4 to 23 times greater for diabetics than for nondiabetics (Table 25). The risk was highest for persons ages 15-44 years, which probably reflects the higher risk of diabetic nephropathy in IDDM patients 20 to 30 years after onset of diabetes.

TABLE 24. *Death certificates with mention of diabetes* and renal disease**, United States, 1979*

Age at Death (Years)	Total Number Listing Diabetes	Number Listing Diabetes and Renal Disease	Percent of Diabetes Death Certificates Mentioning Renal Disease	Total Number Listing Renal Disease	Percent of Renal Death Certificates Mentioning Diabetes
<5	22	3	13.6	1,210	0.3
5-14	60	2	3.3	187	1.1
15-24	262	22	8.4	557	4.0
25-34	878	241	27.5	1,228	19.6
35-44	2,020	342	16.9	2,011	17.0
45-54	6,686	702	10.5	4,806	14.6
55-64	20,662	1,706	8.3	10,910	15.6
65-74	38,743	2,868	7.4	20,407	14.1
75-84	40,650	2,513	6.2	24,540	10.2
85+	18,379	1,069	5.8	16,191	6.6
Unknown	11	0	0.0	5	0.0
Total	128,373	9,468	7.4	82,052	11.5

*ICDA9 codes: 250, 251.0, 648.0, 775.0, 775.1, and 962.3.

**ICDA9 codes: 250.4, 580-589.

SOURCE: 1979 Public Use Mortality Data Tape, National Center for Health Statistics.

TABLE 25. *Renal disease deaths per 100,000 population with and without diabetes as the underlying cause of death, United States, 1979*

Age at Death	Diabetic Renal Mortality Rate*	Nondiabetic Renal Mortality Rate*	Relative Risk Diabetics vs. Nondiabetics
<15	9.26	2.71	3.42
15-44	71.68	3.11	23.08
45-64	93.62	31.83	2.94
65+	321.86	236.44	1.36

*Numerators obtained from death certificates; denominators obtained by multiplying U.S. population by NHIS rates.

SOURCES: 1979 public use mortality data tape and 1979 National Health Interview Survey, National Center for Health Statistics. 1970-1981 Preliminary Estimates of the Population of the United States. U.S. Bureau of the Census. Current Population Reports, Series P-25, No. 917, 1982.

COSTS OF THERAPY FOR DIABETIC ESRD

In 1979, the average Medicare reimbursement for maintenance dialysis was $18,127 per person per year. This included reimbursement for dialysis, physicians, and hospitalizations. If a patient died on dialysis, Medicare reimbursement averaged $28,253 for that year. A successful transplant incurred, on average, $32,067 in Medicare reimbursement during the first year. This included reimbursement for the costs of kidney acquisition, transplantation, back-up dialysis, physicians, and hospitalizations. If the graft failed in the first year, Medicare reimbursement averaged $44,639 and if the patient died in the first year, reimbursement averaged $62,886 for that year. If the graft continued to function after the first year, Medicare reimbursement averaged $4,074 per year for the second and third years. If the graft failed any time after the first year, reimbursement was $30,189 for that year (Eggers 1983).

When average Medicare reimbursement rates are applied to the population with diabetic ESRD, the cost to Medicare of diabetic ESRD is over $280 million per year (Table 16). It is clear, however, that the cost of ESRD therapy is greater in the diabetic population than in the population with ESRD due to other causes. This greater cost is largely due to the poorer outcome of therapy in diabetes and the higher rate of hospitalization of diabetic ESRD patients.

Diabetic hemodialysis patients spent an average of 26 days per year in the hospital; nondiabetic hemodialysis patients spent an average of 19 days per year in the hospital (Shapiro and Comty 1982). IDDM renal transplant recipients spent an average of 81 days in the hospital during the first post-transplant year (and required an average of 1.9 repeat hospitalizations during this year); age/sex/donor-matched nondiabetic renal transplant recipients spent an average of 56 days in the hospital during the first post-transplant year (and required only 0.9 repeat hospitalizations during this year) (Shyh et al. 1983).

One study has reviewed Medicare reimbursement costs for patients with ESRD due to all causes and for patients with ESRD due to diabetic nephropathy. In 1979, the cost to Medicare per patient was 17 percent higher for patients with ESRD due to diabetic nephropathy (Eggers 1985). The total costs to Medicare for diabetic ESRD are probably on the order of $330 million per year (Table 16).

OTHER CONDITIONS AFFECTING THE KIDNEY IN DIABETIC PATIENTS

Infection

A number of studies have demonstrated a higher prevalence of bacteriuria in diabetic women than in nondiabetic women. The prevalence of bacteriuria does not appear to be greater in diabetic children and men than in nondiabetics.

Bacteriuria was found in 18-19 percent of diabetic women and 1-5 percent of diabetic men attending outpatient clinics (Kass 1962, Vejlsgaard 1966). Bacteriuria was more prevalent in patients who had histories of previous instrumentation of the urinary tract, but the prevalence of bacteriuria was greater among women with diabetes even after controlling for instrumentation (Vejlsgaard 1966). Significant bacteriuria was found in 41 percent of women and 18 percent of men with diabetes consecutively admitted to one hospital. Bacteriuria was present in 68 percent of those who had been confined to bed before admission but in only 14 percent of those who had been ambulatory (Rengarts 1960).

Bacteriuria has been detected in 4.4 percent of women and 0.5 percent of men in the general nonhospitalized population (Kass 1962), and in 6-8 percent of nondiabetic women and 2-4 percent of nondiabetic men attending outpatient clinics. Approximately 30 percent of women and 12 percent of men on general medical wards had bacteriuria (Kass 1962). Among a group of 3,057 school children, no boys and only 1 percent of girls showed bacteriuria of more than 100,000 colonies (Kunin et al. 1960). Among 170 insulin-taking diabetic patients ages 6-25 years, no boys and only one girl had urinary tract infections (Etzwiler 1965).

An association has been suggested between urinary tract infection and neurogenic bladder dysfunction or cystopathy. The prevalence of cystopathy among unselected male and female diabetic patients has been estimated to be 44 percent (Frimodt-Moller 1976). The prevalence of both cystopathy and bladder outlet disorders has been associated with increasing age and increasing duration of diabetes (Frimodt-Moller 1980), and cystopathy has also been closely associated with peripheral neuropathy (Buck et al. 1976). In spite of theoretical reasons to presume that bacteriuria should be associated with cystopathy, no relationship between bacteriuria and residual urine volume was found in one study (O'Sullivan et al. 1961).

It is generally believed that there is an increased prevalence of acute pyelonephritis in diabetics (Baldwin and Root 1940, Kleeman and Freedman 1960), but variable diagnostic criteria make the true incidence of acute pyelonephritis difficult to determine. Estimates of the prevalence of acute pyelonephritis in patients with and without diabetes are shown in Table 26. The lower prevalence of acute pyelonephritis as determined by biopsy is not surprising, since the process is often focal and a needle can easily miss the pathology.

The data become even more difficult to interpret when chronic pyelonephritis is considered, because the diagnostic criteria for this disease are particularly unreliable. Based on autopsy data, chronic pyelonephritis has been reported to occur in about 20 percent of diabetic patients (range 12-40 percent) (Aarseth 1953, Baldwin and Root 1940, Blumenthal et al. 1962, Kamenetzky et al. 1974, Sharkey and Root 1935, Young and Clancy 1955), but only in about 3 percent of nondiabetic patients. Based on biopsy data, chronic pyelonephritis has been reported in 9–10 percent of diabetic patients (Gellman et al. 1959, Halverstadt et al. 1966, Thomsen 1961).

TABLE 26. *Number of persons and percent with acute pyelonephritis*

Reference	Source	Year of Publication	Diabetics		Nondiabetics	
			Number	Percent	Number	Percent
a	Autopsy	1944	307	6.8	2,800	1.6
b	Autopsy	1947	859	12.4	31,141	3.3
c	Autopsy	1954	54	14.4	1,715	0.7
d	Biopsy	1961	63	3.1	-	-

TABLE REFERENCES

a. Robbins, SL, and AW Tucker, Jr. Cause of death in diabetes: Report of 307 autopsied cases. N Engl J Med 231:865, 1944.

b. Edmondson, HA, HE Martin, and N Evans. Necrosis of renal papillae and acute pyelonephritis in diabetes mellitus. Arch Int Med 79:148, 1947.

c. Aye, RC. Renal papillary necrosis. Diabetes 3:124, 1954.

d. Thomsen, AC. The significance of renal biopsy for the diagnosis of pyelonephritis in diabetic patients. In: Wolstenholme, GEW, and MP Cameron, eds. Ciba Foundation Symposium on Renal Biopsy. Boston: Little, Brown & Co., 1961. p. 218.

Renal Papillary Necrosis

Renal papillary necrosis arises from ischemic infarction of the inner medulla and papilla of the kidney. Most often, the condition is diagnosed on the basis of a characteristic intravenous pyelogram or at autopsy.

In a large autopsy series, the incidence of renal papillary necrosis was 0.16–0.26 percent in nondiabetics and 2.7–7.2 percent in diabetics (Eknoyan et al. 1982). Among diabetics, papillary necrosis was about 2.5 times more common in women than in men and occurred bilaterally in approximately half of cases (Abdulhayoglu and Marble 1964, Edmondson et al. 1947, Robbins and Tucker 1944). Patients with diabetes and acute pyelonephritis are particularly prone to develop renal papillary necrosis; in one series of 859 autopsied patients with diabetes, papillary necrosis was found in 27 percent of diabetic patients with coexistent acute fulminant pyelonephritis (Edmonston et al. 1947).

In recent years, the incidence of renal papillary necrosis in diabetics appears to have declined. This may be due to a true decrease in incidence resulting from better treatment of urinary tract and renal infections in diabetics. Alternatively, it may reflect the decreased numbers of excretory urograms and autopsies being performed in diabetics. It may also reflect a reporting bias among physicians, who are now more likely to attribute papillary necrosis to other causes, including analgesic abuse and sickle cell disease.

Radiocontrast-Induced Renal Failure

For many years, acute renal failure has been recognized as a potential complication of radiocontrast administration. More recently, diabetes has also been associated with radiocontrast-induced renal failure. Among hospitalized diabetics with normal renal function, the incidence of deterioration of renal function, defined as a rise in serum creatinine of 1.0 mg/dl or more, was about 1 percent following radiocontrast studies (Kumar et al. 1981), whereas the incidence in nondiabetic patients with normal renal function was less than 1 percent (D'Elia et al. 1982, Van Zee et al. 1978).

Several studies indicate that diabetic patients with preexisting renal insufficiency are at increased risk for exacerbation of renal failure following radiocontrast study. Three of 13 diabetic patients with blood urea nitrogen greater than 30 mg/dl and serum creatinine greater than or equal to 1.5 mg/dl had deterioration of renal function following nonrenal angiography (D'Elia et al. 1982). Seven of 12 diabetic patients with serum creatinine levels greater than or equal to 1.5 mg/dl and 15 of 16 with levels greater than 5 mg/dl had renal function deterioration following intravenous pyelography (Van Zee et al. 1978, Harkonen and Kjellstrand 1977). Of 29 diabetic patients with creatinine levels greater than 2 mg/dl, 22 had exacerbations of renal failure following intravenous pyelography; 7 of these had irreversible deterioration of renal function (Harkonen and Kjellstrand 1977). Twelve of 13 patients with juvenile diabetes and advanced chronic renal failure (mean serum creatinine level 6.8 mg/dl) developed renal failure after coronary arteriography (Weinrauch et al. 1977). In addition to preexisting renal insufficiency and diabetes, other conditions that appear to be associated with the development of radiocontrast-induced renal failure are increasing age, dehydration, hypertension, impaired liver function, and multiple myeloma (Alexander et al. 1978, Byrd and Sherman 1979, Swartz et al. 1978, Teruel et al. 1981).

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APPENDIX A. *Annual number of hospital discharges with diabetes and specified kidney diseases, United States, 1976*

Kidney Disease	ICD Number	Age (Years) All	<15	15-44	45-64	65+
Nephritis and renal sclerosis	582, 583, 584	22,514	-	4,238	8,501	9,775
Kidney infections, cystitis	590, 595, 599.0	95,055	244	11,962	31,369	51,480
Nephrotic syndrome	581	2,320	-	453	1,484	383
Other renal diseases	593.2	25,186	146	4,089	6,397	14,544
Proteinuria	789.0	0	-	-	-	-
Uremia	792	0	-	-	-	-
Total		145,075	390	20,742	47,751	76,182

Total number of diabetes hospital discharges = 1,814,000

Percent with an associated kidney diagnosis = 8.0

SOURCE: Cutler, J, NIAMDD, NIH. Analysis of the 1976 Hospital Discharge Survey, National Center for Health Statistics.

APPENDIX B. *Percent of persons who report ever having had kidney trouble, United States, 1976*

	Age (Years)							
	20+		20-44		45-64		65+	
Characteristic	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons 20 years and over	6.8	14.4	5.3	13.4	7.7	14.5	10.2	14.8
Sex								
Men	6.0	12.8	3.7	8.6	7.7	12.9	10.9	14.4
Women	7.6	15.6	6.8	16.2	7.7	16.0	9.7	15.0
Race								
White	7.0	15.3	5.4	13.6	8.0	16.1	10.3	15.1
All other races	5.6	9.7	5.0	12.9	5.2	6.7	9.2	12.3
Black	5.9	9.3	5.3	10.9	5.4	7.1	9.5	11.8

SOURCE: Division of Epidemiology and Health Promotion from 1976 National Health Interview Survey data, National Center for Health Statistics.

APPENDIX C. *Primary diagnosis for new ESRD cases, United States, 1973-80*

Diagnosis	Percent Distribution							
	1973 and prior	1974	1975	1976	1977	1978	1979	1980
Diabetic nephropathy	7.0	11.9	12.2	14.0	15.8	18.0	18.7	21.8
Glomerulonephritis	36.4	29.2	27.1	24.7	23.5	21.7	21.0	19.7
Primary hypertensive disease	13.2	13.9	15.0	15.8	20.4	22.2	22.1	23.4
Polycystic kidney disease	8.7	7.5	6.5	7.0	6.7	6.4	6.1	5.9
Collagen vascular disease	1.5	2.0	1.8	1.8	1.3	1.7	1.4	1.4
Interstitial nephritis, hereditary	1.5	1.4	1.0	1.6	1.2	.7	1.0	1.0
Interstitial nephritis, other	12.5	10.4	10.0	9.4	7.2	6.6	6.7	6.4
Analgesic abuse nephropathy	-	.1	-	.2	1.0	1.0	1.2	1.1
Obstructive uropathy, acquired	.3	.2	.1	.4	2.2	2.5	2.5	2.4
Obstructive uropathy, congenital	.1	.1	.1	.5	1.5	1.3	1.5	1.1
Other causes	9.5	12.5	13.4	12.3	9.4	8.4	7.8	7.0
Etiology unknown	9.0	11.0	12.8	12.4	9.6	9.5	10.1	8.8

SOURCE: Eggers, PW, R Connerton, and M McMullan. The Medicare experience with end-stage renal disease: Trends in incidence, prevalence, and survival. Health Care Financing Review, March 1984.

APPENDIX D. *Probability of survival for one year for Medicare ESRD dialysis patients who have survived for certain years from onset of dialysis, 1973-79*

Age at Onset (Years)	Number of Persons	Year From Onset					
		1	2	3	4	5	6
All persons	74,547	81	83	85	88	88	89
0-14	827	84	88	91	93	97	95
15-24	3,638	88	90	91	93	96	95
25-34	6,833	86	86	89	91	93	93
35-44	9,179	86	85	88	91	91	91
45-54	15,409	85	85	86	87	85	89
55-64	19,897	83	82	84	84	85	88
65-74	14,273	74	77	79	82	81	83
75+	4,491	64	72	72	82	81	91

SOURCE: Eggers, PW, R Connerton, and M McMullan. The Medicare experience with end-stage renal disease: Trends in incidence, prevalence, and survival. Health Care Financing Review, March 1984.

APPENDIX E. *Number and percent of diabetes hospitalizations associated with kidney disease, Pennsylvania*

	Diabetes as Primary Diagnosis		Diabetes as Secondary Diagnosis	
	Number	Percent	Number	Percent
Age				
0-14	1	1.5	1	4.8
15-44	14	5.9	7	1.6
45-64	14	2.7	26	1.5
65+	15	3.2	16	0.6
Sex				
Male	15	3.1	21	1.1
Female	29	3.6	29	1.0
Race				
White	24	2.7	22	0.6
Nonwhite	20	4.9	28	3.0
Total	44	3.4	50	1.0

SOURCE: Pennsylvania Hospital Discharge Survey.

CHAPTER XV. PERIPHERAL VASCULAR DISEASE AND DIABETES

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SUMMARY

Peripheral vascular disease in diabetics includes diminished arterial perfusion to the legs and feet (arteriosclerosis obliterans, ASO), which can lead to ulcers and gangrene, and, in turn, can result in amputation. Eight percent of diabetics have ASO at the time of diagnosis and, by 20 years duration of diabetes, 45 percent have experienced ASO. The incidence of ASO is 3.8 and 6.5 times more frequent in diabetic men and women, respectively, than in their nondiabetic counterparts. There is a threefold excess death rate for diabetics with ASO compared to nondiabetics. Approximately 15 percent of diabetics experience diabetic ulcer on the feet or ankles at some time during their disease. The incidence of gangrene is about 4.5 cases per 1,000 person-years of study, but is 6 to 8 times higher in diabetics who also have ASO. Survival among diabetics who develop gangrene is only 45 percent of the expected survival rate. Diabetes accounts for 40 to 45 percent of all nontraumatic amputations in the United States and occurs annually in about 60 out of every 10,000 diabetics. Occurrence of a second amputation within several years after the first is exceedingly common, and survival for 3 years after an amputation is only about 50 percent.

ARTERIOSCLEROSIS OBLITERANS (ASO)

Impaired blood flow to the legs and feet (arteriosclerosis obliterans, ASO) is commonly encountered among diabetic patients and is associated with such distressing symptoms as pain in the legs during exercise (intermittent claudication) or while resting. The frequency of these symptoms increases with age, may be somewhat greater among men, and is higher among diabetic individuals than among members of the general population. Smoking and the duration of diabetes may be additional risk factors for ASO. Along with other factors such as peripheral neuropathy, such diminished perfusion can lead to ulcers and gangrene, which may result in amputations.

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Measurement of ASO

Perhaps more than any other diabetic complication, the apparent frequency and natural history of peripheral vascular disease (PVD) depends on the measurement technique used, although no technique currently available is entirely satisfactory. Invasive tests (arteriography) measure arterial narrowing and are both sensitive and specific; however, they are expensive and have significant potential risks to patients. Noninvasive physiologic tests (Doppler, plethysmography) measure perfusion. They are sensitive but less specific, and results of the various tests may disagree (Baker et al. 1978, Marinelli et al. 1979). Noninvasive nonphysiologic tests (radiography for arterial calcification) provide an indirect indication of arterial disease that is both insensitive and nonspecific. Absent peripheral arterial pulses on physical examination are an indicator of decreased function that occurs only late in the disease. Such pulse deficits are a relatively insensitive but specific measure; however, observers may disagree about the presence of decreased pulses and these may vary over time (Ludbrook et al. 1962, Meade et al. 1968). Clinical history (claudication) is also an insensitive and nonspecific late indicator of decreased function, and one that is poorly correlated with other clinical indicators of ASO (Widmer et al. 1964).

Incidence of ASO

Population-based studies. Using peripheral pulse deficits as the diagnostic criterion, the incidence of ASO can be estimated for Rochester, Minnesota residents, 30 or more years old and free of ASO at the time of initial diagnosis of diabetes during 1945-69. The incidence was 21.3 per 1,000 person-years of diabetes for men and 17.6 per 1,000 person-years for women (10 years duration of diabetes experienced by one person equals 10 person-years) (Melton et al. 1980). The actuarially estimated cumulative incidence of ASO was 15 percent at 10 years after the initial diagnosis of diabetes and 45 percent after 20 years. If the 8 percent of patients who already had ASO at the time of initial diagnosis of diabetes are included, the overall cumulative incidence is somewhat greater (Figure 1).

Using a history of intermittent claudication as the criterion for ASO, the incidence of ASO among diabetics in the Framingham, Massachusetts population was 12.6 per 1,000 person-years for men and 8.4 per 1,000 person-years for women. Comparable values for those without diabetes were 3.3 and 1.3 per 1,000 person-years for men and women, respectively (Kannel and McGee 1979). Thus, the incidence of ASO in diabetic men was 3.8 times more frequent than in nondiabetic men; for diabetic women, ASO was 6.5 times more frequent. By 16 years after the initial diagnosis of diabetes, 8.8 percent of Framingham diabetics had developed intermittent claudication (Garcia et al. 1974).

Patient studies. Nonpopulation-based data from patients enrolled in the University Group Diabetes Program study of adult-onset diabetes indicate a variable risk for ASO, depending on the diagnostic criteria employed. By 13 years after the start of the study in 1961, the actuarially estimated cumulative incidence of arterial calcification was about 80 percent among men and about 40 percent among women (Kreines et al. 1985). The cumulative incidence of pulse deficits was nearly 50 percent, while the cumulative incidence of intermittent claudication was over 30 percent (Figure 2). In a separate study using a variety of more sophisticated physiologic indicators, ASO was found in 7 percent of a group of diabetic patients free of the disorder 2 years earlier (Bendick et al. 1983).

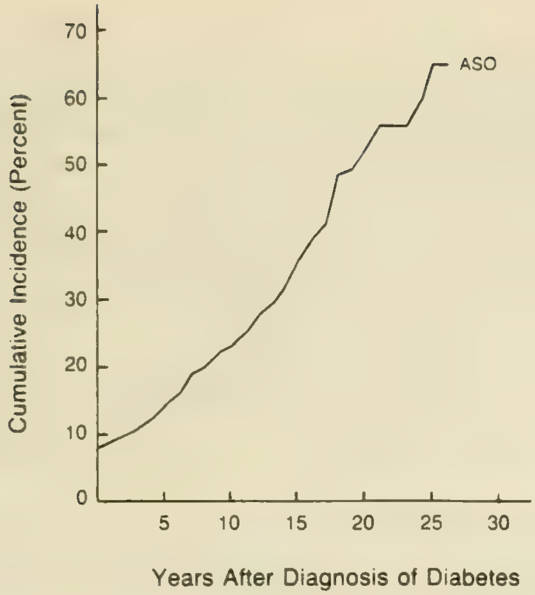

FIGURE 1. *Cumulative incidence of arteriosclerosis obliterans among Rochester, Minnesota residents with diabetes diagnosed between 1945 and 1969*

SOURCE: L.J. Melton, Mayo Clinic, Rochester, Minnesota.

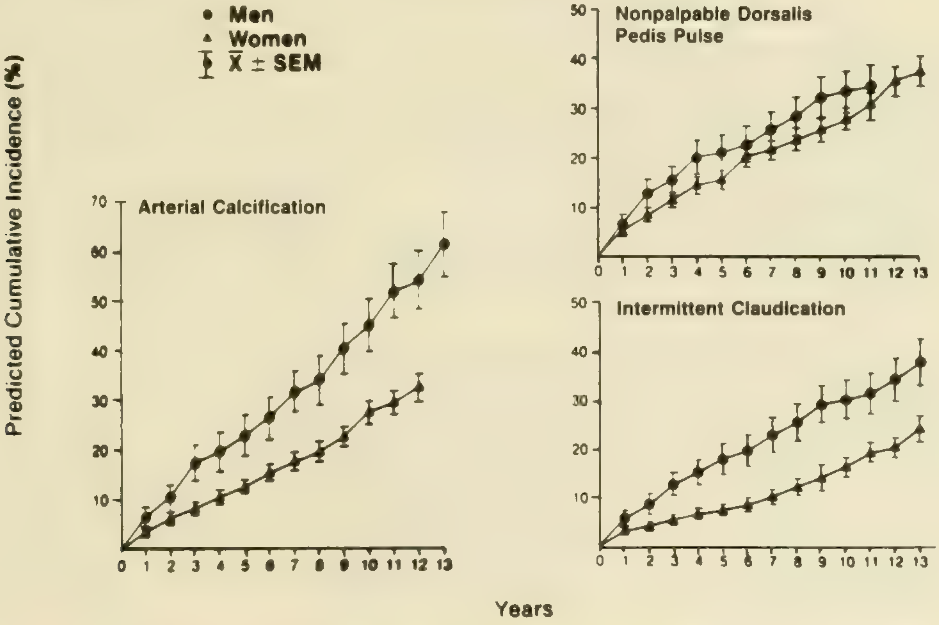

FIGURE 2. *Predicted cumulative incidence of peripheral vascular disease in adult-onset diabetes, University Group Diabetes Program study, 1961 to 1974*

SOURCE: Kreines, K, E Johnson, M Albrink, et al. The course of peripheral vascular disease in noninsulin-dependent diabetics. Diabetes Care, in press, 1985.

Prevalence of ASO

Population-based studies. Using pulse deficits as the criterion for ASO, 8 percent of the Róchester, Minnesota diabetic population diagnosed between 1945-69 had ASO at the time of initial diagnosis of diabetes. Among the prevalent diabetic patients on January 1, 1970, 10.5 percent had ASO, and 3.2 per 1,000 population of Rochester residents had both diabetes and ASO on that date (Melton et al. 1980). Using pulse deficits as the criterion, 9.9 percent of prevalent diabetics in Kristianstad, Sweden had ASO; the comparable figure for the nondiabetic population was 2.6 percent (Nilsson et al. 1967). In the Kristianstad study, when the indicator of moderate or marked arterial calcification was used, ASO of the lower extremity was detected in 16.4 percent of patients with diabetes of short duration (mean duration = 1.5 years) and 38.7 percent of patients with diabetes of long duration (mean duration = 20 years). The comparable figure for the nondiabetic population was 12.2 percent. There are no studies of the prevalence of arterial calcification in the general United States population.

Patient studies. As a result of selective referral, the prevalence of ASO among clinical patients is typically greater than that among diabetic individuals in the general community. Some representative figures, with ASO determined using a variety of diagnostic criteria, are shown in Table 1.

TABLE 1. *Prevalence of arteriosclerosis obliterans (ASO) among diabetic patients as reported from population-based and clinical studies*

			Number of Diabetics Studied and Percent with ASO	
Reference	Type of Study	Measurement	Number	Percent
	Population-based studies			
a	Rochester, Minnesota	Pulse deficits	724	10.5
b	Kristianstad, Sweden	Pulse deficits	374	9.9
	Clinical studies			
c	UGDP subjects	Arterial calcification Pulse deficits Intermittent claudication	997 1,018 1,011	16.1 13.1 5.1
d	Diabetic volunteers	History, physical exam, physiologic tests	430	28.6
e	Hospital patients	Arterial calcification	858	30.5
f	Clinic/hospital patients	Signs or symptoms Years: 1921-41 Years: 1952-56	 2,000 1,600	 19.4 53.7
g	Hospital patients	Signs or symptoms	394	15.7
h	Clinic/hospital patients	Pulse deficits	264	25.4
i	Hospital outpatients	Doppler ultrasound	623	15.9
j	Diabetic volunteers	Doppler and plethysmography	514	38.9
k	Diabetic volunteers	Physiologic tests	426	30.8

(Continued)

TABLE 1. (Continued)

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Mortality, Survival, and Case Fatality Among Diabetics with ASO

Population-based studies. Among Rochester, Minnesota residents with diabetes and ASO as determined by pulse deficits, only 14 percent remained alive after 13 years of diabetes, compared to an expected 42.5 percent survival rate (Figure 3), indicating a threefold excess death rate for diabetics. However, ASO per se increased the mortality rate even in the absence of diabetes. Using the definition of intermittent claudication for ASO, the mortality rate among Framingham residents with ASO but not diabetes was 394 per 10,000 person-years for men and 204 for women, which was 1.9 and 2.3 times greater than expected, respectively (Kannel et al. 1970) (Table 2).

Patient studies. In the University Group Diabetes Program study in 1961-74, mortality rates were 70 to 80 percent greater among diabetics with nonpalpable peripheral pulses upon entry into the study than among diabetics with palpable peripheral pulses (Kreines et al. 1985). In Malmo, Sweden only about 20 percent of 373 diabetic men and women hospitalized with ASO during 1949-65 were alive 10 years later (Figure 4). This survival rate was somewhat worse than that of nondiabetic men with ASO, of whom 40 percent were alive after 10 years. However, there was little difference in survival at 10 years between diabetic and nondiabetic women with ASO (Tibell 1971).

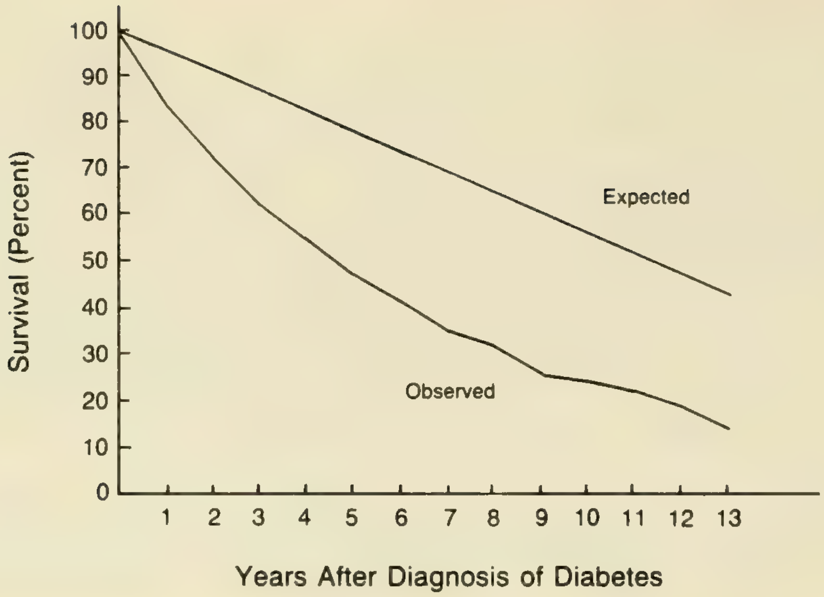

FIGURE 3. *Observed versus expected survival among Rochester, Minnesota residents with diabetes and arteriosclerosis obliterans, 1945-69*

SOURCE: L.J. Melton, Mayo Clinic, Rochester, Minnesota.

TABLE 2. *Incidence of death according to presence of definite intermittent claudication (IC) at examination, for all subjects in the Framingham, Massachusetts population, 1949-63*

Sex and Age (Years) at Exam	Population at Risk at Exam, Summed Over First Seven Exams		Incidence of Death		Average Annual Mortality Rate Per 10,000 Persons		Relative Risk of Death,* with IC/ without IC
	Without IC	With IC	Without IC	With IC	Without IC	With IC	
Men	14,977	292	301	23	100	394	1.9
30-44	4,955	17	23	0	23	0	--
45-54	5,315	63	81	4	76	317	4.2
55-64	3,804	130	136	11	179	423	2.4
65-74	903	82	61	8	338	488	1.4
Women	19,063	196	199	8	52	204	2.3
30-44	6,044	12	19	0	16	0	--
45-54	6,723	56	64	0	48	0	--
55-64	4,992	84	70	5	70	298	4.2
65-74	1,304	44	46	3	176	341	1.9

*Age-adjusted by indirect method using as standard rates the sex-age-specific incidence rates (in 5-year age groups) for the entire study.

SOURCE: Kannel, WB, JJ Skinner Jr, MJ Schwartz, and D Shurtleff. Intermittent claudication. Incidence in the Framingham study. Circulation 41:875-83, 1970.

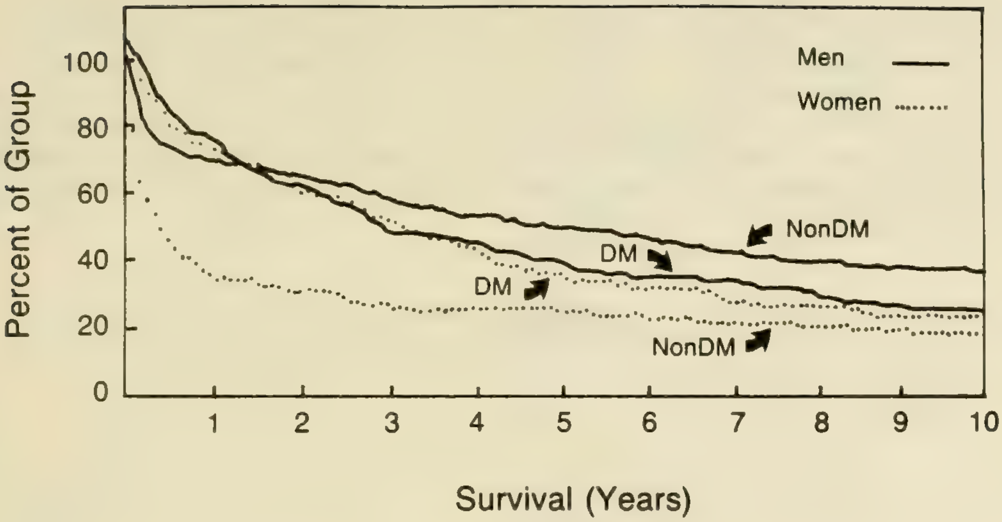

FIGURE 4. *Survival of men and women with or without diabetes and with arteriosclerosis obliterans, having first hospital admission during 1949-65, Malmo, Sweden*

SOURCE: Tibell, B. Peripheral arterial insufficiency. Acta Orthop Scand (Suppl) 139:5-54, 1971.

Risk Factors

Diabetes mellitus. It is only an asumption that all ASO that occurs among individuals with diabetes is etiologically associated; some proportion of cases could be due to chance alone, since the disease also occurs in individuals without diabetes. In the Framingham, Massachusetts population, however, the risk of intermittent claudication was almost five times greater for those with diabetes than for those without it (Kannel and Shurtleff 1971), indicating an etiologic relationship.

Age. No ASO was seen in diabetics below age 40 years in the Rochester, Minnesota population. Above age 40 years, the frequency of ASO increased with age, whether measured by incidence (Table 3) or prevalence (Table 4). However, the incidence of ASO increases with age even in the absence of diabetes, whether measured by intermittent claudication in the Framingham population (Kannel et al. 1970) or by pulse deficits in a population of working people in Basel, Switzerland (Widmer et al. 1964). This observation may explain some of the differences in the relative timing of occurrence of ASO and diabetes when patients of different ages are examined (Figure 5).

Sex. The incidence of ASO among diabetic residents of Rochester, Minnesota was about 20 percent greater among men than women (21.3 versus 17.6 per 1,000 person-years), but the prevalence of ASO was about the same (3.3 versus 3.2 per 1,000) for each sex (Melton et al. 1980). The incidence of intermittent claudication among diabetic subjects in the Framingham study was about 50 percent more among men, but the excess risk for diabetics compared to nondiabetics seemed to be greater among women than among men. Female diabetics had 6.5 times more intermittent claudication than nondiabetic females, and male diabetics had 3.8 times more than nondiabetic males (Kannel and McGee 1979).

TABLE 3. *Incidence of clinical arteriosclerosis obliterans (ASO) subsequent to the diagnosis of diabetes among residents of Rochester, Minnesota who were ASO-free at diagnosis of diabetes, 1945-69*

	Diabetic Men			Diabetic Women		
Age (Years) at Diagnosis of ASO	Number with ASO	Rate* of ASO	95% Confidence Interval	Number with ASO	Rate* of ASO	95% Confidence Interval
30-39	0	0	-	0	0	-
40-59	17	10.7	6.2 - 17.1	7	5.6	2.2 - 11.5
60-79	53	26.8	20.1 - 35.1	58	24.1	18.3 - 31.2
80+	13	84.7	45.1 - 144.8	11	19.8	9.9 - 35.4
Total	83	21.3	17.1 - 26.6	76	17.6	14.0 - 22.2

*Incidence of pulse deficits per 1,000 person-years after diagnosis of diabetes (e.g., 10 years of diabetes for one person equals 10 person-years).

SOURCE: Melton, LJ, KM Macken, PJ Palumbo, and LR Elveback. Incidence and prevalence of clinical peripheral vascular disease in a population-based cohort of diabetic patients. Diabetes Care 3:650-54, 1980.

TABLE 4. *Prevalence of residents with both diabetes and a history of clinical arteriosclerosis obliterans in Rochester, Minnesota on January 1, 1970*

	Diabetic Men			Diabetic Women		
Age (Years) on January 1, 1970	Number	Prevalence Rate*	95% Confidence Interval	Number	Prevalence Rate*	95% Confidence Interval
30-39	0	0	-	0	0	-
40-59	3	0.7	0.1 - 2.0	5	1.0	0.3 - 2.3
60-79	20	9.2	5.6 - 14.2	26	7.2	4.7 - 10.5
80+	11	30.8	15.4 - 55.1	11	13.1	6.5 - 23.4
Total	34	3.3	2.3 - 4.6	42	3.2	2.3 - 4.3

*Prevalence of pulse deficits per 1,000 population ages 30 years and older.

SOURCE: Melton, LJ, KM Macken, PJ Palumbo, and LR Elveback. Incidence and prevalence of clinical peripheral vascular disease in a population-based cohort of diabetic patients. Diabetes Care 3:650-54, 1980.

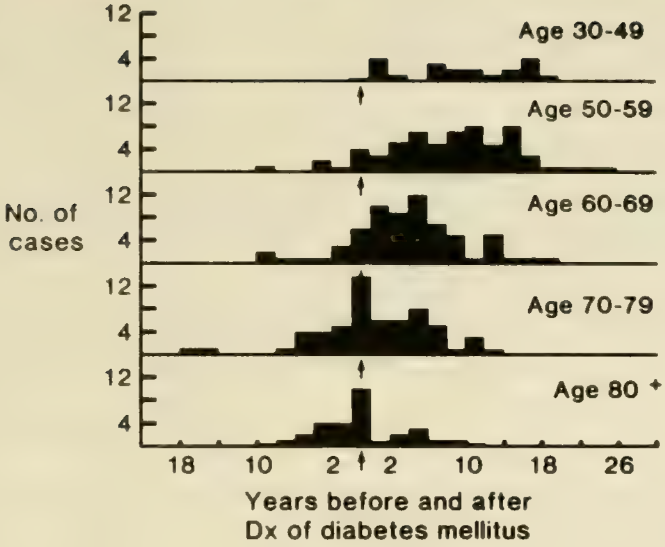

FIGURE 5. *Relative timing of the clinical diagnosis of peripheral vascular disease among diabetic residents of Rochester, Minnesota, 1945-69, by age at onset of diabetes*

SOURCE: Melton, LJ, KM Macken, PJ Palumbo, and LR Elveback. Incidence and prevalence of clinical peripheral vascular disease in a population-based cohort of diabetic patients. Diabetes Care 3:650-54, 1980.

Duration of diabetes. In the Rochester, Minnesota population, the incidence of ASO as measured by pulse deficits seemed to increase with increasing duration of diabetes even when age was taken into account (Table 5). The same phenomenon was observed when the prevalence of pulse deficits was studied in the Kristianstad, Sweden population (Table 6).

Other risk factors. In Framingham, the risk of intermittent claudication increased with ever greater levels of blood glucose. The observed incidences of claudication were 52, 135, and 396 percent of the expected incidences, respectively, for patients with casual blood glucose determinations of 80-99 mg/dl, 100-129 mg/dl, and 130-420 mg/dl (Kannel and Shurtleff 1971). The University Group Diabetes Program study found a relationship between initial glucose tolerance test levels and the subsequent risk of arterial calcification and pulse deficits (Kreines et al. 1985). That study also documented an increased risk of arterial calcification with greater serum triglyceride levels, as well as a relationship between pulse deficits and obesity. Systolic blood pressure has also been associated with the risk of arterial calcification among diabetic patients (Beach and Strandness 1980, Kreines et al. 1985), but in Framingham the relative risk of intermittent claudication was 2.3 for hypertensive versus normotensive subjects even in the absence of diabetes (Kannel and Shurtleff 1971). In a clinical study of volunteers, there were more smokers among diabetic patients with ASO than among diabetic individuals without vascular disease (Zimmerman et al. 1981). Others have found similar correlations in diabetics (Beach and Strandness 1980), and smoking has been linked especially with progression of ASO (Strandness and Beach 1982).

There is some evidence that the risk is reduced by the cessation of smoking (Beach and Strandness 1983). In Framingham, the risk of intermittent claudication among all subjects with a history of coronary heart disease was 3.6 times higher than among those without such a history; this relationship has not been explored for diabetics (Kannel and Shurtleff 1971).

TABLE 5. *Incidence of clinical arteriosclerosis obliterans (ASO) subsequent to the diagnosis of diabetes among residents of Rochester, Minnesota who were ASO-free at diagnosis of diabetes, by age and duration of diabetes, 1945-69*

Age (Years) at Diagnosis of ASO	Duration of Diabetes					
	Under 5 Years		5-10 Years		Over 10 Years	
	Number	Rate*	Number	Rate*	Number	Rate*
30-39	0	0	0	0	0	0
40-59	12	7.5	6	7.2	6	14.8
60-79	46	22.2	32	22.8	33	36.3
80+	10	33.0	6	25.3	8	47.1
Total	68	16.2	44	17.3	47	31.6

*Incidence of pulse deficit per 1,000 person-years of diabetes.

SOURCE: Melton, LJ, KM Macken, PJ Palumbo, and LR Elveback. Incidence and prevalence of clinical peripheral vascular disease in a population-based cohort of diabetic patients. Diabetes Care 3:650-54, 1980.

TABLE 6. *Frequencies (percent) of different degrees of pulsation of feet-arteries at different ages in diabetes of short (A) and long (B) duration compared with nondiabetic persons (N)*

	Palpable			Partly Palpable			Not Palpable		
	N	A	B	N	A	B	N	A	B
Males									
60-79	60.0	40.0	45.0	37.1	28.6	22.5	2.9	31.4	32.5
40-59	95.2	80.1	66.7	4.8	8.3	26.2	0	11.1	7.1
20-39	96.8	90.0	100.0	3.2	10.0	0	0	0	0
Mean	84.0	70.0	70.6	15.0	15.6	16.2	1.0	14.2	13.2
Females									
60-79	60.7	52.6	33.3	32.1	31.6	51.3	7.1	15.8	15.4
40-59	80.6	76.7	53.3	13.9	23.3	46.7	5.6	0	0
20-39	88.2	81.8	73.7	11.8	18.2	4.1	0	0	5.3
Mean	76.5	70.4	53.4	19.3	24.4	34.0	4.2	5.3	6.9
M + F mean	80.3	70.2	62.0	17.2	20.0	25.1	2.6	9.8	10.1

SOURCE: Nilsson, SE, JE Nilsson, N Frostberg, and T Emilsson. The Kristianstad Survey II. Acta Med Scand [Suppl] 469:1-42, 1967.

DIABETIC ULCER

Simple definitions of diabetic ulcer are difficult to devise because of the possibility of different or combined etiologies. For example, occlusive arterial disease (OAD) of the lower extremities could involve either small vessel occlusion in the toes, large vessel occlusion in the legs and feet, or both. Neuropathy can lead to neurotropic ulcers, while varicose ulcers could be superimposed, along with the additional effects of trauma or infection. Moreover, there may be an underlying vascular component to the ulcerations that develop in diabetics, but this ulceration may not be typically diabetic or exclusively related to diabetes. Since ulcerations can occur in other circumstances, this condition is not specific for diabetes and, therefore, can only be used as evidence of progression of peripheral vascular disease among diabetic individuals when it is associated with clinical or laboratory evidence of occlusive arterial disease.

Incidence, Prevalence, and Mortality

No data are available on the incidence of diabetic ulcers. The prevalence of a history of ulcers or sores on the feet or ankles was 15 percent among all diabetic individuals identified in the population-based study in southwestern Wisconsin but was higher among diabetics diagnosed before 30 years of age (Table 7). No data on mortality exist because death is unlikely to result from ulcer per se, but rather from systemic infections, gangrene, or surgical complications.

Risk Factors

In the Wisconsin population in 1980-82, the prevalence of a history of ulcer was slightly higher among men (16.2 percent) than women (13.4 percent) and was greater among diabetic individuals taking insulin (16.8 percent) than among those not on insulin (9.8 percent). The prevalence increased with age, especially in diabetics diagnosed under the age of 30 (Table 7).

TABLE 7. *Percent of diabetic patients with a history of ulcers or sores on the feet or ankles, Wisconsin Epidemiology Study of Diabetic Retinopathy (WESDR), 1980-82*

Diabetes Diagnosed at Age <30 Years		Diabetes Diagnosed at Age ≥30 Years	
Age (Years)	Percent	Age (Years)	Percent
<15	3.5	30-35	0
15-24	9.7	35-44	11.4
25-34	12.1	45-54	13.0
35-44	21.9	55-64	13.2
45-54	30.8	65-74	15.6
55+	36.8	75-84	17.0
		85+	17.7

SOURCE: R. Klein, University of Wisconsin, personal communication.

GANGRENE

Gangrene is defined as focal or extensive necrosis of the skin and underlying tissue, but difficulties exist with this definition. As in the case of ulcers, there are several etiologies for gangrene. One is occlusive arterial disease (OAD) of large and/or small vessels, but infection and neuropathy may also play a role. Gangrene is better correlated with OAD than are ulcers of the toe or foot, however. The demonstration of clinical or subclinical OAD would be essential if gangrene were to be deemed a manifestation of the progression of OAD in the individual diabetic patient.

Incidence and Prevalence

Population-based studies. In Rochester, Minnesota, the incidence of new episodes of gangrene among diabetic residents initially free of any peripheral vascular disease was 4.5 per 1,000 person-years of study (Table 8). Among diabetics with ASO, the incidence of gangrene was much higher, being 29.6 per 1,000 person-years in men and 37.1 per 1,000 person-years in women (Melton et al. 1980). Prevalence is a less satisfactory indicator of the importance of gangrene than incidence because of the poor survival experienced by these patients and their loss from the prevalent population. In Rochester the prevalence of gangrene among diabetic patients on January 1, 1970 was 0.8 percent (Table 8) or 0.03 percent of the total population 30 years old or over (Melton et al. 1980).

Patient studies. As in the case of ASO, the prevalence of gangrene is greater in selected diabetic patient populations than it is in the general community (Table 8).

Mortality, Survival, and Case Fatality

Among Rochester, Minnesota residents with diabetes who also developed gangrene, survival was poor, as only 39 percent remained alive after 2 years. This figure was 45 percent of the expected survival rate for people of like age and sex (Melton, 1984). During 1950-67, gangrene listed on United States death certificates was about 20 times more common among diabetic than among nondiabetic deaths (Langberg et al. 1971). In Louisiana in 1978, 41 percent of all death certificates that mentioned gangrene also mentioned diabetes (Louisiana, 1978). In the United States in that year, 7.2 percent of all death certificates mentioning gangrene also mentioned diabetes (Harris, 1978).

Risk Factors

The risk factors for gangrene have not been quantified for diabetic patients. However, in the general population, as judged from hospital discharge data, the risk of gangrene is greater for men than women (25.1 versus 15.4 discharges per 100,000 population per year, respectively) and rises with age (4.5, 19.5, and 128.5 discharges per 100,000 per year, respectively, for people 15 to 44 years old, 45 to 64 years old, and 65+ years old) (USDHHS 1980). Overall in the United States in 1978, there were about 43,000 hospital discharges for gangrene, or about 20.1 per 100,000 population per year.

TABLE 8. *Incidence and prevalence of gangrene among diabetic patients*

Reference	Type of Study	Incidence Per 1,000 Person-Years of Study	Number of Diabetics Studied and Percent with Gangrene: Number	Percent
	Population-based studies			
a	Rochester, Minnesota, without ASO	4.5	724	0.8
	Males with ASO, age 30+ years	29.6	326	0.0
	Females with ASO, age 30+ years	37.1	398	1.5
	Clinical studies			
b	Clinic/hospital patients	-	3,600	6.4
c	Veterans Administration hospital discharges	-	21,293*	10.2*
d	Hospital patients	-	774	5.9
e	Autopsied diabetic deaths	-	1,854	29.3
f	Autopsied diabetic deaths	-	1,470	12.7

*Diabetes discharges that mention either gangrene or ulcer.

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AMPUTATIONS

As with the other manifestations of PVD, not all amputations are related to occlusive arterial disease (OAD). Amputations may be carried out for gangrene due to other causes, for ulcerations related to neuropathy and infection, for osteomyelitis, or for trauma and accidental injury. Before it can be declared that an amputation is related to OAD, there must be clinical evidence that OAD did indeed exist prior to the amputation. As a rule, toe amputations can be related to infection, neuropathy, and/or OAD, but leg and thigh amputations are almost always due to OAD. Therefore, leg and thigh amputations generally might be considered to be due to OAD without introducing great error.

Incidence and Prevalence

Population-based studies. Data from hospital discharges in six States in 1976-78 provide an estimate for the incidence of lower extremity amputations of 59.7 per 10,000 diabetic individuals per year (Table 9). Amputations among diabetics accounted for 45 percent of all lower extremity amputations performed in these

States (Most and Sinnock 1983). In the entire United States in 1978, 89,000 hospital discharges involved an amputation; diabetes was present in 35 percent of these, and for persons aged 45 years and older, diabetes accounted for 41 percent (Table 10).

TABLE 9. *Estimated United States amputation rates* for diabetics and nondiabetics and distribution of all amputations by type, 1978*

Age (Years)	Rate Per 10,000 Non-Diabetics	Rate Per 10,000 Diabetics				Type (Percent)		
		Total	Male	Female	Male/Female	Toe	Foot	Leg
0-44	0.5	14.1	27.1	10.3	2.6	56.5	6.8	36.7
45-64	1.9	45.0	63.2	38.0	1.7	39.9	6.5	53.6
65+	9.9	101.4	132.1	90.9	1.4	24.4	3.2	72.4
Total	2.0	59.7	77.3	54.3	1.4	30.5	4.4	65.1

*Based on hospital discharges in six States and extrapolated to the United States population of 1978.

SOURCE: Most, RS, and P Sinnock. The epidemiology of lower extremity amputations in diabetic individuals. Diabetes Care 6:87-91, 1983.

TABLE 10. *Hospital discharges involving both diabetes and amputations, United States, 1978*

Condition Mentioned in the Discharge	Age (Years)								
	0-44			45-64			65+		
	Number	% of All Diabetes Discharges	% of All Amputations Discharges	N	% DM	% Amp	N	% DM	% Amp
Diabetes	349,000	100.0	-	726,000	100.0	-	985,000	100.0	-
Amputation	17,000	-	100.0	22,000	-	100.0	50,000	-	100.0
Both diabetes and an amputation	1,766	0.5	10.4	9,492	1.3	43.0	19,726	2.0	39.4

*ICDA 8th edition codes 85.0 to 85.9: Amputations of fingers, thumb, hand, forearm, elbow, arm, shoulder, interthoracoscapular amputation; amputation of toes, foot, leg, thigh, knee, hip joint.

SOURCE: Harris, MI, National Diabetes Data Group. From unpublished data of the 1978 Hospital Discharge Survey, National Center for Health Statistics.

Prevalence data are poor indicators of the number of amputations among diabetics because of frequent death of these patients. Table 11 shows that the prevalence of an amputation reported in the 1977 National Health Interview Survey was substantially greater among diabetics than among nondiabetics, however. The rates among diabetics were similar to those found in the Wisconsin diabetic population, where the prevalence of a history of amputations was 0.8 percent for toe, 1.4 percent for below the knee, and 0.4 percent for above the knee (Klein 1984). The national rates in the 1964-65 survey were virtually identical to those in 1977 (Table 11).

TABLE 11. *Self-reported absence of a lower extremity, fingers, or toes per 1,000 persons among diabetics (DM) and nondiabetics (nonDM), United States, 1977*

	Age (Years)							
	20+		20-44		45-64		65+	
	DM	nonDM	DM	nonDM	DM	nonDM	DM	nonDM
Absence of lower extremity	14.4	1.4	-	0.6	12.2	1.7	23.2	3.5
Absence of entire fingers or toes	24.4	12.2	24.6	7.4	22.9	15.8	26.5	21.9

SOURCE: Drury, T, from unpublished data of the 1977 Health Interview Survey, National Center for Health Statistics. In 1964-65, 14 per 1,000 diabetics reported absence of a lower extremity and 22 per 1,000 reported absence of fingers or toes.

Patient studies. Among adult-onset diabetics studied during 1961-73 in the University Group Diabetes Program study, 1.3 percent experienced a major amputation (Kreines et al. 1985). The WHO multinational study in 1974-78 found 2.2 percent of 3,301 diabetic men and 1.2 percent of 3,394 diabetic women with a history of any amputation (WHO 1980). In a study in the 1950s of a group of 394 hospitalized diabetics, 8 percent had amputations (Bryfogle and Bradley 1957). Subsequent amputations are relatively common among diabetics who have already experienced an amputation. In one amputee cohort, 67 percent had a partial amputation of the remaining leg within 5 years (Goldner 1960). The mortality rate among diabetic amputees is high. The 3-year survival rate in one group of patients was only 50 percent (Whitehouse et al. 1968).

Risk Factors

Diabetes. It is generally believed that amputations are more frequent among diabetic patients than among people without this disorder. The incidence of lower extremity amputations for diabetic and nondiabetic individuals shows a 25-fold or greater excess for diabetics, and the relative risk appears to be highest among younger people (Table 9). The National Health Interview Survey of 1977 revealed that the reported absence of a lower extremity was five to eight times greater, depending on age, among individuals with diabetes than among nondiabetics. Absence of fingers and toes was up to three times more common among diabetic patients (Table 11).

Age, sex, and race. The incidence of amputations as ascertained through hospital discharge records increases with age among diabetic individuals (Tables 9 and 10). Prevalence data show this less clearly, perhaps because of poor survival among such patients (Table 11). The trend to increased rates of amputation with age is seen for the whole United States population, although as noted above, almost half of these amputations occur among diabetics. Diabetes-related amputations appear to be more common among men than women (Table 9), although the same phenomenon is seen for amputations in the population at large (USDHHS, 1980). One study indicated that amputation rates are substantially greater for nonwhite diabetics than for white diabetics (Van Buskirk et al. 1983), and a study of all hospital discharges in South Carolina in 1978 found that black diabetics have an amputation rate 2.3 times greater than white diabetics (Most and Sinnock 1983).

Other factors. The ischemic extremity is susceptible to gangrene, infection, and ulceration. There is usually an associated neuropathy which also predisposes to ulceration in the diabetic patient. The nondiabetic patient requiring amputation usually has more severe OAD than the diabetic patients who undergo this procedure.

Mortality

Death after an amputation in a diabetic is a frequent event. Survival rates are about 50 percent for the following 3 years and about 40 percent during the 5 years following an amputation (Table 12).

TABLE 12. *Survival after amputation in diabetic patients*

Reference	Location	Study Year	Number of Cases	Survival
a	Joslin Clinic	Before 1946	206	50% for 3 years
b	Private practice, N.Y.	Before 1948	-	40% for 3 years
c	Private practice, N.Y.	1942-52	237	65% for 3 years 41% for 5 or more years
d	Henry Ford Hospital Detroit, Michigan	1956-65	67	50% for 3 years 36% for 5 years

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APPENDIX A. *Average annual incidence of intermittent claudication per 10,000 population, Framingham, Massachusetts, 1949-63*

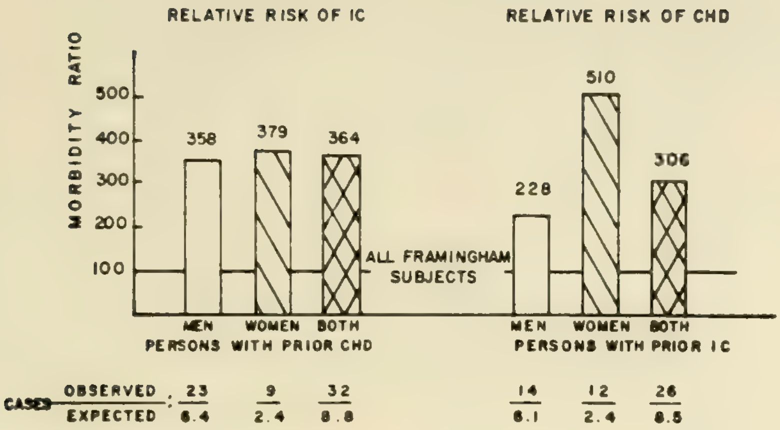
Age (Years) at Exam	Male Rate/10,000	Female Rate/10,000
30-44	6	3
45-54	19	7
55-64	53	18
65-74	61	54
Total 30-74	26	12

SOURCE: Kannel, WB, JJ Skinner Jr, MJ Schwartz, and D Shurtleff. Intermittent claudication. Incidence in the Framingham study. Circulation 41:875-83, 1970.

APPENDIX B. *Prevalence of occlusion of peripheral arteries (OPA) in the Basel, Switzerland study of an employed population, 1960-63*

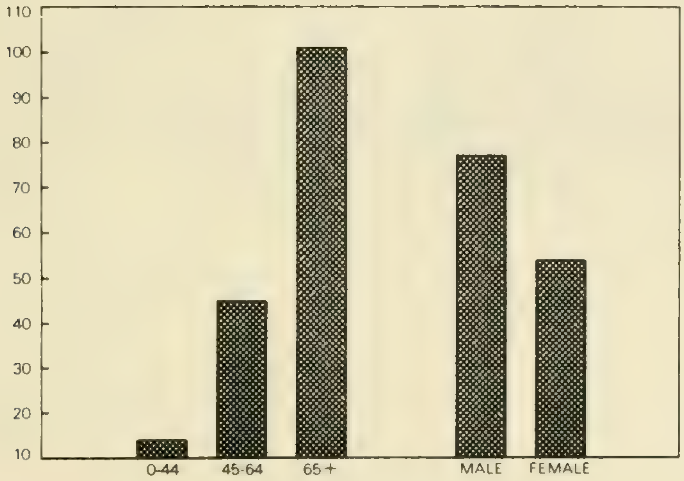
	Men		Women	
Age (Years)	Number of Persons Examined	Percent with OPA	Number of Persons Examined	Percent with OPA
15-19	177	-	118	-
20-24	256	0.4	330	-
25-29	479	0.4	282	-
30-34	704	0.1	215	-
35-39	769	0.4	193	0.8
40-44	654	0.9	129	-
45-49	659	0.9	106	0.9
50-54	547	3.6	92	2.1
55-59	347	5.2	37	2.6
60-64	153	7.5	-	-

SOURCE: Widmer, LK, A Greensher, and WB Kannel. Occlusion of peripheral arteries: A study of 6,400 working subjects. Circulation 30:836-52, 1964.



APPENDIX C. *Relative risk of intermittent claudication (IC) and coronary heart disease (CHD) among all persons in the Framingham study, 1948-62*

SOURCE: Kannel, WB, JJ Skinner Jr, MJ Schwartz, and D Shurtleff. Intermittent claudication. Incidence in the Framingham study. Circulation 41:875-83, 1970.



APPENDIX D. *Estimated incidence (number per 10,000 diabetics) of amputation, by age and sex, United States, 1978*

SOURCE: Sinnock, P, PC Holman, R Most, and S Teutsch. Assessment of diabetes morbidity/mortality data in diabetes control program states. In: Proceedings of the 5th Annual Diabetes Control Conference, May 10-13, 1982, Lexington, KY.

APPENDIX E. *Lower extremity amputations per 10,000 estimated population, selected states, 1976 and 1977*

	Ampuations Per 10,000 Diabetics		Amputations Per 10,000 Nondiabetics	
State	1976	1977	1976	1977
Maine	62.6	66.2	1.8	2.1
Rhode Island	87.9	90.9	NA	1.8
South Carolina	49.2	NA	1.7	NA

Age Group	Number	Rate
<15	0	0.0
15-34	6	4.0
35-44	6	13.2
45-64	111	119.0
65+	238	440.1
Total	361	81.2

SOURCE: Centers for Disease Control, Diabetes Control Activity.

APPENDIX F. *Rate of hospital discharges for amputations per 100,000 persons, United States, 1978*

	Age (Years)				Sex		
	<15	15-44	45-64	65+	All	Men	Women
Toe	2.0	5.3	14.5	48.3	10.9	14.1	8.0
Foot	0.4	1.1	4.4	9.3	2.5	3.2	1.9
BK Leg	0.4	1.9	12.6	73.9	11.4	14.8	8.2
AK Leg	0.4	1.4	11.2	76.7	11.2	12.1	10.4

SOURCE: U.S. Department of Health and Human Services. Detailed diagnoses and surgical procedures for patients discharged from short-stay hospitals: United States 1978. DHHS Pub. No. (PHS) 80-1274. Washington, DC, 1980.

APPENDIX G. *Rate of amputations in diabetic patients in the Wisconsin Epidemiology Study of Diabetic Retinopathy, 1980-82*

Current Age (Years)	Number of Patients Studied	Duration-Adjusted Rate Per 100 Population		
		Toes	Below Knee	Above Knee
Insulin-taking patients diagnosed prior to age 30 years				
0-24	433	0	0	0
25-34	289	0	0.7	0
35-44	137	2.9	4.4	0
45-54	79	2.5	3.8	0
55-64	46	4.3	6.5	2.2
65+	12	0	8.3	0
Total	996	0.9	1.6	0.1
Patients diagnosed at age 30+ years				
30-44	49	0.4	0	0
45-54	161	0.2	0.2	0
55-64	358	1.3	2.0	0.4
65-74	468	1.0	1.5	1.2
75-84	270	0.1	1.2	1.1
85+	64	0.5	1.3	0
Total	1,370	0.8	1.2	0.6

SOURCE: R. Klein, University of Wisconsin. Personal communication.

CHAPTER XVI. DIABETES AND HEART DISEASE

Elizabeth Barrett-Connor, M.D., and
Trevor Orchard, M.D.

SUMMARY

The single most common cause of death in adults with diabetes mellitus in the United States is atherosclerotic coronary heart disease, which accounts for at least one-third of all deaths occurring in diabetics after age 40. Heart disease is more common in diabetics than nondiabetics. The excess risk occurs in both insulin-dependent and noninsulin-dependent diabetics and is not clearly related to the duration of diabetes. In contrast to nondiabetics, heart disease in diabetics appears earlier in life, affects women almost as often as men, and is more often fatal. The heart disease is usually of the same type as seen in nondiabetics, but, as shown by X-rays of the coronary arteries or by examination of the heart postmortem, occlusion of the coronary arteries is generally more extensive and severe. Persons with diabetes are more likely than those without diabetes to have characteristics that are associated with an increased risk of heart disease, particularly high blood pressure, certain lipid abnormalities, and clotting (platelet) abnormalities. There is also some evidence that diabetics who smoke cigarettes are at greater risk of heart disease than nondiabetics who smoke. Treatment or elimination of these risk factors would be expected to reduce the diabetic's risk of heart attack. Some of the increased risk of heart attack is independent of these factors, however. Further studies are needed to determine whether improved control of diabetes and/or the use of newer treatments will reduce the excess risk of heart disease in diabetics.

METHODOLOGIC PROBLEMS IN ASSESSING DIABETES AND HEART DISEASE

The assessment of data on the relationship between diabetes and heart disease is difficult for several reasons. There are problems with the diagnosis of both diseases. The definition of diabetes varies in different studies, most diagnostic criteria previously used would not now be acceptable, and studies of older adults rarely distinguish insulin-dependent from noninsulin-dependent diabetes. Similarly, the criteria for both

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fatal and nonfatal heart disease vary from study to study, lack good sensitivity and specificity, and may not distinguish nonatherosclerotic from coronary artery disease. Studies using more definitive criteria for macrovascular heart disease, such as angiography and autopsy studies, suffer from the bias that subjects selected for investigation have disease more severe than that seen in a total population.

Prevalence studies of clinical, electrocardiographic, and angiographic disease in diabetics all suffer from survivorship bias; that is, they are studies of persons who have these diseases who are still alive. Thus, they do not include diabetics who have already died from heart disease. For example, fatal coronary artery disease in a large proportion of diabetics could yield the false impression that diabetics who are alive are at less, rather than greater, risk of coronary artery disease. Prevalence studies also suffer from bias of ascertainment, i.e., the greater probability that coronary artery disease will be diagnosed in diabetics because they are more likely to be thoroughly examined for heart disease than other patients.

Studies derived from clinic populations also suffer from selection bias (i.e., diabetics with complications such as heart disease, hypertension, or other cardiovascular risk factors are more likely to be in clinic populations) and from bias of ascertainment (i.e., heart disease is more likely to be looked for in patients who have diabetes). Similarly, diabetics identified from hospital records or specialty clinics are more likely to have known cardiovascular disease than those derived from population samples, because the former are more thoroughly examined for the presence of heart disease. Studies derived from population samples usually suffer from broader or less specific definitions of diabetes and coronary artery disease.

PREVALENCE OF HEART DISEASE IN DIABETICS

United States Survey Estimates

The self-reported prevalence of a heart condition in persons with a medical history of diabetes in the 1976 United States Health Interview Survey ranged from 7.5 percent to 16.6 percent (Table 1). A self-report of a heart condition or heart attack was 1.6 to 2.5 times more common in diabetic versus nondiabetic men, and 1.7 to 4.0 times more common in diabetic versus nondiabetic women; in both sexes, the prevalence ratio in subjects ages 45-65 years was greater than in those ages 65+ years. The prevalences of heart failure and heart attack reported in the 1976-80 Health and Nutrition Examination Survey were also higher for diagnosed diabetics than for persons with normal glucose tolerance (Table 2). Among all outpatient visits involving diabetes in the 1977 National Ambulatory Medical Care Survey, 17.5 percent also involved some form of heart disease, with ischemic heart disease reported in 11 percent of all physician office visits by diabetics (Table 3).

Community-Based and Patient Studies

More specific, but less representative, data on the prevalence of clinically manifested ischemic heart disease in diagnosed diabetics come from the Rochester, Minnesota study of 1,028 maturity-onset diabetics (Table 4) and studies of Dupont employees and college cohorts (Table 5). The latter two studies permit comparisons with nondiabetics and show prevalence ratios of 2.6 and 1.6 in diabetic men compared to nondiabetic men, similar to the ratios of self-reported heart conditions in the national survey in Table 1.

TABLE 1. *Percent of persons reporting a heart condition or previous heart attack, United States, 1976*

	Age 45-64 Years			Age 65+ Years		
	Diabetics*	Nondiabetics	Ratio	Diabetics	Nondiabetics	Ratio
Males						
Heart condition**	7.5	3.6	2.1	15.6	9.5	1.6
Heart attack	11.0	4.4	2.5	15.1	8.4	1.8
Females						
Heart condition	13.7	4.2	3.3	16.6	9.7	1.7
Heart attack	5.6	1.4	4.0	8.9	4.3	2.1

*Diabetes was ascertained by positive responses to the questions "Do you have diabetes or sugar diabetes?" and "Did a doctor tell you that you have it?"

**Based on responses to the interview questions "Have you ever had a heart attack?" and "Have you ever had any other heart trouble?" (Data are for white respondents only.)

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

TABLE 2. *Percent of persons reporting a medical history of physician-diagnosed cardiovascular conditions, United States, 1976-80*

Reported Medical History and Glucose Tolerance Status*	Age (Years)				
	20-74	20-44	45-54	55-64	65-74
Rheumatic fever					
Diagnosed diabetics	2.7	1.0	3.7	2.6	3.3
Undiagnosed diabetics	2.8	0	0	4.1	5.4
IGT	2.5	3.0	1.4	3.4	2.2
Normal	2.5	2.5	3.0	2.2	1.9
Rheumatic heart disease					
Diagnosed diabetics	1.4	0	1.8	2.2	1.4
Undiagnosed diabetics	0.7	0	0	2.1	0
IGT	0.9	3.0	0	0	0.9
Normal	0.6	0.4	1.5	0.8	0.5
Heart murmur					
Diagnosed diabetics	9.4	11.5	5.0	13.6	7.2
Undiagnosed diabetics	6.9	0	0	17.5	5.2
IGT	8.8	5.6	7.1	9.0	14.0
Normal	7.7	8.6	5.8	7.1	7.0
Heart failure					
Diagnosed diabetics	3.4	0.8	2.1	6.1	3.6
Undiagnosed diabetics	1.2	0	0	0	4.4
IGT	3.3	0	3.4	3.8	6.1
Normal	0.9	0.5	0.9	1.6	1.9
Heart attack					
Diagnosed diabetics	11.3	0	11.7	13.6	16.1
Undiagnosed diabetics	8.2	0	0	17.3	9.9
IGT	5.4	0	5.8	6.9	9.0
Normal	2.5	0.4	1.7	6.9	10.2
Any other heart trouble					
Diagnosed diabetics	13.5	5.8	13.1	12.0	20.6
Undiagnosed diabetics	14.3	4.7	13.9	14.7	19.7
IGT	10.8	4.0	5.0	22.9	11.8
Normal	4.3	1.7	6.6	8.0	10.2

*National Diabetes Data Group criteria applied to the results of 2-hour, 75-gram oral glucose tolerance tests; IGT=impaired glucose tolerance.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

TABLE 3. *Prevalence of heart diseases in visits involving diabetes to office-based physicians, United States, 1977*

Specified Heart Disease Diagnosis (ICD Number)	Diabetes As Any-Listed Diagnosis (Total = 18.8 Million)		Diabetes as First-Listed Diagnosis (N=11.0 Million) Number (Thousands) With		Diabetes as Second-Listed Diagnosis (N=6.1 Million) Number (Thousands) With		Diabetes as Third-Listed Diagnosis (N=1.7 Million) Number (Thousands) With	
	Percent With Heart Disease	Number (Thousands) With Heart Disease	Specified Diagnosis Second-Listed	Specified Diagnosis Third-Listed	Specified Diagnosis First-Listed	Specified Diagnosis Third-Listed	Specified Diagnosis First-Listed	Specified Diagnosis Second-Listed
Hypertensive heart disease (402)	0.5	100.1	13.3	--	25.6	--	44.4	16.8
Chronic ischemic heart disease (412)	11.0	2,081.5	666.9	149.4	563.0	245.7	342.5	114.0
Angina pectoris (413)	1.8	324.1	30.2	40.2	50.4	33.9	21.7	147.8
Symptomatic heart disease (427)	4.0	738.2	272.1	56.2	108.8	140.1	19.1	141.9
Other myocardial insufficiency (428)	0.2	36.0	9.7	--	--	--	6.6	19.7

SOURCE: Adapted from Sayetta, RB, and RS Murphy. Summary of current diabetes-related data from the National Center for Health Statistics (National Ambulatory Medical Care Survey). Diabetes Care 2:116, 1979.

TABLE 4. *Percent of 1,028 maturity-onset diabetic patients with coronary heart disease and congestive heart failure, by sex and age at the time of diagnosis of diabetes mellitus, Rochester, Minnesota, 1945-1969*

Age at Diagnosis of Diabetes (Years)	Coronary Heart Disease*			Congestive Heart Failure**		
	Male	Female	Both Sexes	Male	Female	Both Sexes
<60	8.3	5.2	6.9	2.0	1.6	1.8
≥60	20.9	15.7	18.1	12.9	9.7	11.2
Total	14.7	11.7	13.2	7.5	6.7	7.1

*Includes angina pectoris and myocardial infarction.

**Without antecedent coronary or valvular heart disease.

SOURCE: Palumbo, PJ, LR Elveback, and DC Connolly. Coronary heart disease and congestive heart failure in the diabetic. In: Scott, RC, ed. Clinical Cardiology and Diabetes. Vol. 1. Mount Kisco, NY: Futura, 1981. p. 18.

TABLE 5. *Prevalence of clinically manifested ischemic heart disease (IHD) in male diabetics*

Reference	Population	Definitions of IHD	Definitions of Diabetes	Prevalence (Percent)		Prevalence Ratio
				Diabetic	Nondiabetic	
a	Dupont employees and age-matched controls (median age 50 years)	Myocardial infarct coronary insufficiency and/or angina pectoris	Not specified, but 184 of the 370 diabetics (50%) were on insulin	7.56	2.97	2.6
b	College cohorts (age 47 ± 9 years)	Self-report of physician-diagnosed coronary heart disease	Self-report of doctor-diagnosed diabetes with onset after age 24	2.21	1.42	1.6

TABLE REFERENCES

a. Pell, S, and CA D'Alonzo. Factors associated with long-term survival of diabetics. JAMA 214:1833-40, 1970.
b. Paffenbarger, Jr, RS, and AL Wing. Chronic disease in former college students. XII. Early precursors of adult-onset diabetes mellitus. Am J Epidemiol 97:314-23, 1973.

Table 6 shows the prevalence of abnormalities on resting electrocardiograms (ECG) in studies published since 1970. The prevalence of definite myocardial infarction in males by Minnesota Code criteria differed little or not at all in diabetics versus nondiabetics, possibly reflecting survivorship bias. The prevalence of ECG abnormalities based on other criteria in diabetic versus nondiabetic men always exceeded 1.0, with prevalence ratios ranging from 1.1 to 2.7. The single study of Caucasian women with a nondiabetic comparison group showed a higher prevalence ratio of 3.9. Interestingly, in Pima Indians, who have a high prevalence of diabetes but a low prevalence of ischemic heart disease, definite ECG abnormalities in women were seen only in diabetic women; the male prevalence ratio was 1.4. Not shown in the table are data from the WHO Multinational Study of Vascular Disease in Diabetics, which reported large geographic differences in the prevalence of ECG abnormalities in diabetics. For example, the prevalence of major Q wave abnormalities was 0.4 percent in Hong Kong women compared to 10.5 percent in Berlin women (Jarrett 1984). Unfortunately, ECGs were not coded centrally and the data published to date are not age-adjusted, so the significance of these differences remains unclear.

TABLE 6. *Prevalence of abnormalities on resting electrocardiogram in diabetics and nondiabetics*

Reference	Year of Publication	Population	Prevalence/1,000		Prevalence Ratio	Criteria for ECG Abnormality
			Diabetes	No Diabetes		
a	1970	Clinic series of 90 newly diagnosed diabetic women ages 35-75 years, and controls	230	59	3.9	Major ST abnormalities (Minnesota Code)
b	1976	Pima Indians 40+ years				
		Males	290	210	1.4	Major Q wave (Minnesota Code)
		Females	270	0	--	
c	1979	Paris study of male civil servants ages 42-53 years	145.3	56.6	2.6	Whitehall
			112.7	42.0	2.7	Pooling Project
d	1979	Chicago industry male employees ages 40-59 years	7.4	7.2	1.0	Definite myocardial infarction (Minnesota Code)
			115.0	98.3	1.2	Whitehall
			98.3	89.2	1.1	Pooling Project
d	1979	Chicago People's Gas Company; males ages 40-64 years	29.4	29.2	1.0	Definite myocardial infarction (Minnesota Code)
			188.4	134.8	1.4	Whitehall
			101.6	96.2	1.1	Pooling Project
e	1980	Whitehall study of male civil servants ages 40-64 years	9.5	7.0	1.4	Major Q wave (Minnesota Code)
			27.9	12.6	2.2	ST depression (Minnesota Code)
			91.6	59.6	1.5	Whitehall

TABLE REFERENCES

a. Weaver, JA, SK Bhatia, et al. Cardiovascular state of newly discovered diabetic women. Br Med J 1:783-86, 1970.

b. Ingelfinger, JA, PH Bennett, IM Liebow, and M Miller. Coronary heart disease in the Pima Indians. Electrocardiographic findings and postmortem evidence of myocardial infarction in a population with a high prevalence of diabetes mellitus. Diabetes 25:561-65, 1976.

c. Ducimetiere, P, E Eschwege, et al. Relationship of glucose tolerance to prevalence of ECG abnormalities and to annual mortality from cardiovascular disease. J Chron Dis 32:759-66, 1979.

d. Stamler, R, J Stamler, JA Schoenberger, et al. Relationship of glucose tolerance to prevalence of ECG abnormalities and to 5-year mortality from cardiovascular disease. J Chronic Dis 32:817-28, 1979.

e. Fuller, JH, MJ Shipley, G Rose, RJ Jarrett, and H Keen. Coronary heart disease risk and impaired glucose tolerance: The Whitehall Study. Lancet 1:1373-76, 1980.

Table 7 shows a consistently higher prevalence of ST depression on ECG during or after exercise in diabetics versus nondiabetics. In general, nondiabetics exercised longer and attained a higher heart rate than diabetics. In contrast to this evidence for an excess of ischemic heart disease in adult diabetics, one computer study, not shown in the table, reported that 40 young insulin-dependent diabetic men had significantly less ST depression at both onset and end of exercise, but a slower return of the ST segment to the resting level, than 26 age-matched nondiabetics (Campbell 1975).

TABLE 7. *Exercise electrocardiograms in adult diabetics and nondiabetics*

Reference	Location and Year of Publication	Number and Sex		Mean Age (Years)		Percent with Pathological ST Depressions		Prevalence Ratio
		Diabetics	Controls	Diabetics	Controls	Diabetics	Controls	
a	Sweden, 1966	84 male	76 male	33	33	27	9	3.0
b	Sweden, 1977	76 male	46 male	42	42	50	26	1.9
c	United States, 1981*	17 female	9 female	40	38	47	33	2.1
d	United States, 1976*	19 male & female	18 male & female	30	29	5	0	--
e	United States, 1981*	16 male	12 male	49	49	13	8	1.5

*Subjects with symptomatic or resting ECG evidence of ischemic heart disease excluded.

TABLE REFERENCES

a. Karlefors, T. Circulatory studies during exercise with particular reference to diabetics. Acta Med Scand [Suppl] 449:180, 1966.
b. Persson, G. Exercise tests in male diabetics. Acta Med Scand [Suppl] 605:7-23, 1977.
c. Rubler, S. Asymptomatic diabetic females. NY State J Med 7:1185-91, 1981.
d. Rubler, S, and SB Arvan. Exercise testing in young asymptomatic diabetic patients. Angiology 27:539-48, 1976.
e. Abenavoli, T, S Rubler, VJ Fisher, HI Axelrod, and KP Zuckerman. Exercise testing with myocardial scintigraphy in asymptomatic diabetic males. Circulation 63:54-64, 1981.

Among diabetics with no clinical evidence of coronary artery disease, angiographic studies of coronary arteries have been performed only in insulin-dependent diabetics with end-stage renal disease who were being evaluated for renal transplantation. At least half of these young patients had multifocal and/or hemodynamically significant coronary atherosclerosis (Bennett et al. 1978, Weinrauch et al. 1978). Among diabetic patients with symptoms suggestive of coronary artery disease, six angiographic studies of the coronary arteries are shown in Table 8. In two of the four studies with nondiabetic comparison groups, angiographically documented coronary artery disease was more severe and more apt to be triple vessel disease in diabetics; patients in the two studies showing no association with diabetes were those referred for possible coronary artery bypass and may reflect selection bias favoring more severe disease in nondiabetics. Although Hamby and Sherman (1979) found more disease in diabetics of longer duration, Draskoczy et al. (1974) did not (Table 8). In the multicenter Coronary Artery Surgery Study (Vlietstra 1980), 8,807 consecutive patients undergoing coronary arteriography for clinically suspected coronary artery disease were dichotomized into those with and without coronary artery disease. Disease was defined as one or more

TABLE 8. *Angiographic studies in patients with symptoms of ischemic heart disease according to diabetic status*

Reference	Year of Publication	Study Population	Percent with Multivessel Disease	
			Diabetics	Nondiabetics
a	1974	36 diabetics (mean age 52 years)	78	--
b	1975	35 diabetics (mean age 59 years)* 77 nondiabetics (mean age 55 years)*	57	58
c	1977	42 diabetics (mean age 54 years)* 42 nondiabetics (mean age 54 years)*	71**	67
d	1978	37 diabetics (mean age 56 years) 79 nondiabetics (mean age 54 years)	43	25
e	1979	80 diabetics ≤1 year's duration* 57 diabetics ≥10 years' duration*	35 68	-- --
f	1980	34 diabetics (mean age 56 years) 120 nondiabetics (mean age 50 years)	91	70

*All patients selected for possible coronary bypass.

**"Jeopardy" score ≥8.

TABLE REFERENCES

a. Draskoczy, SP, OS Leland, and RF Bradley. Aorto-coronary bypass in the diabetic patient. Kidney Int [Suppl 1] 6:S37-S40, 1974.
b. Verska, JJ, and WJ Walker. Aortocoronary bypass in the diabetic patient. Am J Cardiol 35:774-77, 1975.
c. Dash, H, RA Johnson, RE Dinsmore, CK Francis, and JW Harthorne. Cardiomyopathic syndrome due to coronary artery disease. II. Increased prevalence in patients with diabetes mellitus: A matched pair analysis. Br Heart J 39:740-47, 1977.
d. Dortimer, AC, PN Shenoy, RA Shiroff, DM Leaman, JD Babb, AJ Liedtke, and R Zelis. Diffuse coronary artery disease in diabetic patients. Circulation 57:133-36, 1978.
e. Hamby, RI, and L Sherman. Duration and treatment of diabetes. Relationship to severity of coronary artery disease. NY State J Med 10:1683-88, 1979.
f. Vigorita, C, S Betocchi, G Bonyani, et al. Severity of coronary artery disease in patients with diabetes mellitus. Am Heart J 100:782-87, 1980.

coronary artery segments showing stenosis of 50 percent or greater. After consideration of other risk factors, diabetes was a weak predictor of angiographically demonstrated coronary artery disease and was significant only in women ages 46-65.

Nonatherosclerotic Diabetic Heart Disease

There seems little reason to doubt that both Type I and Type II diabetics are at increased risk of heart disease that is indistinguishable epidemiologically, pathologically, or clinically from the atherosclerotic heart disease seen in nondiabetics. For example, in a recent clinical study, diabetics with ischemic heart disease resembled nondiabetics with ischemic heart disease in more ways than they differed (Smith et al. 1983). There is, however, increasing evidence that some diabetics also have another form of heart disease (Regan 1983, Shapiro 1982). The epidemiological evidence rests largely on observations in Framingham, Massachusetts, where diabetics, particularly women treated with insulin, had an excess risk of congestive heart failure unexplained by coexisting coronary heart disease or by the presence of standard coronary risk factors (Kannel et al. 1974, Kannel and McGee 1979a).

Diabetic patients without signs or symptoms of cardiovascular disease have shown altered isovolumetric relaxation time (Rubler et al. 1978) and systolic time intervals (Ahmed et al. 1975, Zoneraich et al. 1978). Young diabetics who, on the basis of age, would be unlikely to have significant obstructive disease of the major coronary arteries, have shown impaired left ventricular function compatible with a subclinical cardiomyopathy based on echocardiographic study (Friedman et al. 1982, Lababdidi et al. 1981, Sandersen 1978). An excellent review of functional heart disease in diabetics has been provided recently by Shapiro (1984).

Pathological evidence for small-vessel disease in diabetic hearts includes nonspecific findings of intimal proliferation, thickened walls (Hamby et al. 1974, Pearce et al. 1973, Rubler et al. 1972, Zoneraich et al. 1980), and perivascular fibrosis (Ledet 1976). Characteristic lesions of diabetic microangiopathy, thickening of the capillary basement membrane (Fischer et al. 1979), and microaneurysms (Factor et al. 1980) have also been observed. Lesions of intraluminal small vessels have not been observed by all investigators (Crall and Roberts 1978, Regan et al. 1977). In one autopsy study, diabetics who died in heart failure and had no significant narrowing of the coronary arteries or intramural vessels had widespread accumulation of PAS-positive material in the left ventricular interstitium and interstitial fibrosis (Regan et al. 1977). The frequency, cause, and relationship of this nonatherosclerotic cardiac pathology and its relationship to the increased morbidity and mortality associated with coronary artery disease in diabetics remain to be elucidated.

Autopsy Studies

Autopsy data have generally shown more extensive arteriosclerosis in diabetics than in nondiabetics. The most extensive pathological study of atherosclerosis involving diabetics is the International Atherosclerosis Project (Robertson 1968), in which the degree of atherosclerosis was assessed in more than 34,000 autopsies from 13 centers. The importance of the reported geographic differences is difficult to assess because of the small number of diabetics in each age and sex group by country. Overall, diabetics had significantly more fatty streaks and raised lesions in the coronary arteries, even when cases with associated hypertension were excluded from the analysis. Diabetics also had more fibrous plaques, more coronary stenosis, more complicated lesions, and more calcification than nondiabetics.

Review of published necropsy studies of coronary artery narrowing in patients with "maturity-onset" diabetes shows that, in studies with a nondiabetic comparison group, diabetics were 1.2 to 6.6 times more likely to have coronary artery narrowing (Table 9). Overall, coronary narrowing by atherosclerotic plaques was found in 38 percent of 5,484 patients with known diabetes, compared to 6 percent of 50,154 nondiabetic subjects. The studies in Table 9 have several deficiencies, however. Most of the data were obtained from autopsy protocols without reexamination of the hearts, coronary narrowing was not quantified, and subjects used as controls were usually not matched for age and sex.

The degree of atherosclerotic plaque in the four major coronary arteries was examined in 65 diabetics with no clinical evidence of coronary artery disease, 164 diabetics with clinical coronary artery disease, and 183 nondiabetics with clinical coronary artery disease, all of whom were patients at the Mayo Clinic. The only significant differences found, comparing diabetics to nondiabetics with coronary artery disease, were a higher frequency of severe narrowing of the left main coronary artery and healed transmural left ventricular scars. The amount of coronary artery disease in

TABLE 9. *Necropsy studies of coronary-artery narrowing by atherosclerotic plaque or thrombus in diabetes mellitus patients with onset after age 30 years*

First Author	Year of Publication	Number of Diabetics Studied	Number (and Percent) of Diabetics with Coronary Artery "Narrowing"	Number of Nondiabetics Studied	Number (and Percent) of Nondiabetics with Coronary Artery "Narrowing"
Warren	1925	18	7(39)	--	--
Wilder	1926	49	17(24)	--	--
Root	1926	17	7(41)	--	--
Gibb	1929	120	19(16)	--	--
Blotner	1930	77	35(45)	450	95(21)
Nathanson	1932	97	41(42)	249	21(8)
Enklewitz	1934	74	23(31)	520	77(16)
	1934	87	19(22)	95	16(17)
	1934	100	79(79)	--	--
Root	1936	175	74(42)	170	13(8)
Root	1939	329	180(55)	2,650	683(26)
Pollack	1941	113	64(57)	--	--
Stearns	1942	50	37(74)	400	148(37)
Lisa	1942	193	90(47)	2,095	656(31)
Millard	1948	98	67(34)	--	--
Clawson	1949	1,113	196(18)	37,062	2,883(8)
Warren	1952	761	193(25)	--	--
Feldman	1954	135	60(44)	1,182	238(20)
Goldenberg	1958	256	131(51)	2,580	615(24)
Goodale	1962	65	40(62)	847	164(19)
Warren	1966	1,854	726(40)	1,854	226(12)
Total		5,484	2,087(38)*	50,154	3,240(6)*

*p<.01

SOURCE: Waller, BF, PJ Palumbo, JT Lie, and WC Roberts. The heart in diabetes mellitus as viewed from a morphologic perspective. In: Scott, RC, ed. Clinical Cardiology and Diabetes. Vol. 1. Mt. Kisco, NY: Futura Inc., 1981. pp. 83-125.

diabetics did not correlate with age at onset of diabetes, duration of diabetes, type of treatment, or apparent degree of glycemic control (Waller et al. 1980).

A 1968-78 study from Johns Hopkins compared the autopsy findings of 185 "maturity-onset" diabetics with age- and sex-matched controls and found that, on the average, diabetics had significantly more overall coronary artery disease, more diffuseness of coronary disease, more coronary collaterization, more vessels involved by atherosclerosis, and more myocardial infarction (Table 10). However, the degree of atherosclerosis was unrelated to the severity or duration of diabetes (Vigorita et al. 1980a).

INCIDENCE OF NONFATAL CARDIOVASCULAR DISEASE

IDDM. There is little information on the incidence of nonfatal ischemic heart disease in diabetics. Most data on juvenile or insulin-dependent diabetics are limited to myocardial infarction, derive from clinical series, and afford no comparison with nondiabetics (Deckert et al. 1978, Dorman et al. 1984, Kerr et al. 1952, Paz-Guevara et al. 1975). In these patient studies, the incidence of nonfatal myocardial infarction varied from 0 to 21 percent (Table 11). Two other studies limited to long-surviving diabetics, i.e., 26-46 years (Ryan et al. 1970) and 40-51 years (Oakley et al. 1974), each found a myocardial infarction rate of 9 percent.

TABLE 10. *Comparison of coronary artery disease in 185 diabetics and 185 age- and sex-matched nondiabetics, ages 37-91 years*

Variable	Mean ± standard deviation Diabetics	 Nondiabetics	p (t-test)
Overall coronary arterial atherosclerosis	49.9 ± 29.7	39.7 ± 31.5	<0.002
Number of diseased coronary arteries	1.4 ± 1.2	1.0 ± 1.2	<0.001
Diffuseness of coronary atherosclerosis	41.6 ± 29.1	32.8 ± 29.8	<0.005
Coronary arterial collaterals	32.1 ± 32.1	20.7 ± 31.7	<0.001
Epicardial coronary arterial tortuosity	52.8 ± 17.3	55.5 ± 16.3	<0.1
Number of myocardial infarcts	1.2 ± 1.2	0.8 ± 0.9	<0.001

SOURCE: Vigorita, VJ, GW Moore, and GM Hutchins. Absence of correlation between coronary arterial atherosclerosis and severity or duration of diabetes mellitus of adult onset. Am J Cardiol 46:540, 1980.

TABLE 11. *Myocardial infarction (MI) in insulin-dependent diabetics*

Reference	Location and Year of Publication	Number of Patients Studied	Age (Years) at Onset of Diabetes	Years Studied	Percent Experiencing MI
a	Toronto, 1952	77	<16	Mean 15	4
b	Cincinnati, 1965	101	<16	Mean 16	0
c	Boston, 1975	73	<15	40+	16
d	Copenhagen, 1978	264	<31	40+	21
e	Pittsburgh	531	<17	17+	2

TABLE REFERENCES

a. Kerr, RB, GD Brown, and N Kalant. A follow-up study of juvenile diabetics. Can Med Assoc J 66:97-104, 1952.

b. Knowles, HC. Long-term juvenile diabetes mellitus and unmeasured diet. In: Proceedings of the 7th Congress of International Diabetes Federation, August 1970, Buenos Aires. pp. 209-15.

c. Paz-Guevara, AT, TH Hsu, and P White. Juvenile diabetes mellitus after forty years. Diabetes 24:559-64, 1975.

d. Deckert, T, JE Poulson, and M Larsen. Prognosis of diabetics with diabetes onset before the age of thirty-one. Diabetologia 14:363-70, 1978.

e. Dorman, J, E LaPorte, LH Kuller, K Cruickshanks, TJ Orchard, DK Wagener, DJ Becker, D Cavender, and AL Drash. The mortality experience of 1,893 insulin-dependent diabetic patients: The Pittsburgh experience. Submitted for publication.

NIDDM. In older adults, a modest excess relative risk of angina pectoris and a more striking excess risk of congestive heart failure as the first manifestation of ischemic heart disease in diabetics versus nondiabetics has been reported from Framingham and Rochester (Table 12). In Framingham, the excess risk of congestive heart failure was largely confined to female diabetics being treated with insulin (Kannel et al. 1974). There was also an excess risk of myocardial infarction in both populations. Unfortunately, these analyses did not distinguish fatal from nonfatal myocardial infarction.

TABLE 12. *Relative risk of angina pectoris, congestive heart failure, and myocardial infarction in diabetics versus nondiabetics*

Reference	Location of Study, Age of Patients, and Duration of Study	Sex	Relative Risk, Diabetics vs. Nondiabetics		
			Angina Pectoris	Congestive Heart Failure	Myocardial Infarction
a	Framingham, MA, 45-74 years, 18-year followup	Men	1.6	3.8	1.5
		Women	1.9	5.5	2.6
b	Rochester, MI, 30+ years, >3,000 person-years of followup	Men	1.7	3.0	2.4
		Women	2.4	2.5	4.7

TABLE REFERENCES

a. Shurtleff, D. Some characteristics related to incidence of C-V disease and death: Framingham Study 18-year follow-up. Washington, DC: Supt. of Docs., U.S. Govt. Print. Off., 1974.

b. Palumbo, PJ, LR Elveback, and DC Connolly. Coronary heart disease in the diabetic: Epidemiological aspects. The Rochester Diabetes Project. In: Scott, RC, ed. Clinical Cardiology and Diabetes. Vol. 1. Mount Kisco, NY: Futura Publishing Company, Inc., 1981. pp.13-27.

RISK FACTORS FOR DEVELOPMENT OF HEART DISEASE IN DIABETICS

Duration and Control of Diabetes

Among 920 diabetics in Rochester diagnosed in 1945-69 and free of heart disease at diagnosis, the frequency of reported ischemic heart disease by duration of diabetes was 13 percent by 5 years, 28 percent by 10 years, 39 percent by 15 years, and 51 percent by 20 years (Palumbo 1985). However, in distinct contrast to the situation with regard to microvascular disease in diabetics, where both duration and glucose level usually relate to subsequent diabetic retinopathy and renal disease, no published studies have convincingly demonstrated an association that is independent of age between the duration of diabetes and either the risk or the severity of ischemic heart disease. Similarly, "control of diabetes," i.e., the level of hyperglycemia, appears to be unrelated to heart disease risk. Some of the difficulty in defining the relationship between glucose control or duration of diabetes and the development of complications of diabetes may stem from the difficulty in defining duration of diabetes and in defining adequate glycemic control. In addition, the failure to demonstrate a correlation of diabetic macroangiopathy and duration or severity of diabetes may be due to the more multifactorial etiology of atherosclerotic vascular disease, in contrast to microangiopathy, which may be more specifically related to the degree of hyperglycemia.

Hyperglycemia

The diagnosis of diabetes depends on blood glucose levels. It may, therefore, be inappropriate, particularly in population-based studies where relatively few determinations are usually available, to use blood glucose levels both as diagnostic criteria and as criteria for severity or control of diabetes. Data from persons without diabetes, however, can be used to explore the relationship of hyperglycemia per se to heart disease. The results of these studies are conflicting. Glucose intolerance has been found in over 60 percent of patients with coronary artery disease proven at angiography (Table 13). The International Collaborative Group (1979) found no significant association (relative risk less than 2.0) of glucose quintile with coronary heart disease mortality in 8 of 11 studies of middle-aged men in eight countries (Table 14). In multivariate analysis, only one population showed a significant association of coronary heart disease mortality with postload glucose, and in this population there was a significant inverse association of cardiovascular death with casual glucose levels.

TABLE 13. *Frequency of glucose intolerance in patients with angina pectoris who had angiographically confirmed coronary artery disease*

Reference	Year of Publication	Number of Patients	Percent with "Glucose Abnormality"
a	1967	135	64
b	1970	70	63
c	1975	216	65

TABLE REFERENCES

a. Herman, MV, and R Gorlin. Coronary artery disease and diabetes mellitus. In: Hamwi, GJ, and TS Danowski, eds. Diabetes Mellitus: Diagnosis and Treatment. New York: American Diabetes Association, Inc., 1967. p.185.

b. Falsetti, HL, JD Schnatz, DG Greene, and IL Bunnell. Serum lipids and glucose tolerance in angiographically proved coronary artery disease. Chest 58:111-15, 1970.

c. Barner, HB, GC Kaiser, JE Codd, and VL Willman. Coronary graft flow and glucose tolerance evidence against the existence of myocardial microvascular disease. Vascular Surgery 9:220-27, 1975.

TABLE 14. *Summary of 11 studies by the International Collaborative Group relating baseline glucose and cardiovascular mortality*

Studies	Number Showing Positive Association	Number Showing No or Negative Association
Univariate analyses		
Death rates in highest versus lowest glucose quintile		
All deaths	8	4
Cardiovascular deaths	5	7
Coronary heart disease deaths	7	5
Death rates in highest glucose quintile (≥50 men) versus all men		
All deaths	5	1
Cardiovascular deaths	4	2
Coronary heart disease deaths	3	3
Multivariate analyses (studies with 10 or more deaths)		
All deaths	3	9
Cardiovascular deaths	1	11
Coronary heart disease deaths	1	10

SOURCE: Stamler, J, and R Stamler. Maturity onset diabetes and asymptomatic hyperglycemia. In: Moskowitz, J, ed. Diabetes and Atherosclerosis Connection. New York: The Juvenile Diabetes Association, 1981. p. 38.

Four studies in the International Collaborative Group, having at least 100 men in the upper 2 to 5 percent stratum of the postload glucose distribution, were analyzed to test for a glucose threshold effect; two showed higher coronary heart disease rates in this stratum and two did not (Table 15). However, reexamination of the Whitehall study conducted in England suggested that a threshold effect does exist, with an increased risk of mortality in men whose 2-hour postload plasma glucose was above the 95th percentile (96-199 mg/dl) (Fuller et al. 1980). Similarly, a Paris prospective study of 6,589 nondiabetic men ages 42 to 53 years found a twofold excess risk of cardiovascular death in men with impaired glucose tolerance (2-hour postload glucose of 140-199 mg/dl) (Eschwege 1980). A 10-year study in Bedford, England also found that borderline hyperglycemia (120-199 mg/dl at 2 hours after 50 gm glucose) carried an excess risk of coronary heart disease mortality, but only in women (Jarrett et al. 1982). In Rancho Bernardo, California fasting plasma glucose less than 140 mg/dl was significantly and independently predictive of fatal ischemic heart disease in men (whether plasma glucose was analyzed as a categorical or continuous variable) but this association was not seen in women (Barrett-Connor et al. 1984). It is possible that studies showing no association reflect a lack of power due to the small number of events and/or misclassification bias resulting from use of postchallenge glucose with its greater intra-individual variability (Liu et al. 1982).

TABLE 15. *Risk ratios for cardiovascular mortality by glucose test in the International Collaborative Group study*

Glycemia Test	Location and Study Population	Risk Ratio
Fasting	Helsinki, Finland Police Study	1.40
	Denmark, 50 year	1.44
1-Hour post-load	Chicago Heart Association Detection Project	0.90
	Finland, Social Insurance Institution Study	1.33
	Australia	1.52
	Helsinki, Finland Police Study	2.49
	U.S., Peoples Gas Company Study*	6.07
2-Hour post-load	Switzerland	0.86
	U.S., Western Electric Company Study*	0.96
	England	0.98
	Helsinki, Finland Police Study	1.86
	France	2.30
Casual	U.S., Peoples Gas Company Study*	0.34
	Scotland	1.41

*Hypertensives under treatment included.

SOURCE: Stamler, J, and R Stamler. Maturity onset diabetes and asymptomatic hyperglycemia. In: Moskowitz, J, ed. Diabetes and Atherosclerosis Connection. New York: The Juvenile Diabetes Association, 1981. p. 38.

Insulin

Insulin has been postulated as an independent atherogenic risk factor. In population studies, insulin levels have been predictive of cardiovascular disease mortality in men, but were not predictive in the only study of women to date (Table 16). There are some recent data to suggest that the DNA sequences flanking the insulin gene on chromosome 11 confer a risk of atherosclerosis that is independent of classical heart disease risk factors (Mandrup-Poulsen et al. 1984). Although insulin-dependent diabetics who survive past age 40 may have a greater risk of ischemic heart disease than noninsulin-dependent diabetics of the same age, the evidence that exogenous insulin is a risk factor for ischemic heart disease is weak. In the University Group Diabetes Program study, the risk of ischemic heart disease was similar in the insulin-treated and placebo groups (Klimt et al. 1970).

TABLE 16. *Prospective population-based studies showing the relationship of plasma insulin to coronary heart disease*

Reference	Study Location	Duration of Study	Age (Years)	Number and Sex	Post-Glucose Time (Hours)	Significance of Risk Ratio for Coronary Heart Disease*
a	Helsinki, Finland	5 years	30+	1,034 men	0 1 2	$p < 0.05$ $p < 0.001$ $p < 0.001$
b	Paris, France	5 years	43-54	7,246 men	0 2	$p < 0.01$ $p < 0.01$
c	Busselton, Australia	6 years	21+	1,634 men 1,697 women	1	$p < 0.01$ not significant

*Risk ratio determined by comparing top quintile of insulin with combined lower quintiles. Insulin measured after 50-gram oral glucose in Finland and Australia, and after 75-gram in France. Coronary heart disease defined as nonfatal myocardial infarction in Finland, as nonfatal infarction and CHD death in France, and as angina pectoris, myocardial infarction, and/or frank ECG changes in Australia.

TABLE REFERENCES

a. Pyorala, K. Relationship of glucose tolerance and plasma insulin in the incidence of coronary heart disease: Results from two population studies in Finland. Diabetes Care 2:131-41, 1979.
b. Ducimetiere, P, E Eschwege, JL Papoz, et al. Relationship of plasma insulin levels to the incidence of myocardial infarction and coronary heart disease mortality in a middle-aged population. Diabetologia 19:205-10, 1980.
c. Welborn, TA, and K Wearne. Coronary heart disease incidence and cardiovascular mortality in Busselton with reference to glucose and insulin concentrations. Diabetes Care 2:154-60, 1979.

Lipids and Lipoproteins

Triglyceride is not presently thought to be an independent risk factor for coronary heart disease (Hulley et al. 1980), but cholesterol level has been identified as a major risk factor. Published reports on the levels of cholesterol and triglycerides in diabetics are conflicting. In population-based studies, diabetic adults in both Framingham (Kannel and McGee 1979c) and Rancho Bernardo (Barrett-Connor et al. 1982) had significantly higher triglyceride but not higher cholesterol levels than nondiabetics from the same community. Data from clinics have shown higher cholesterol and triglyceride levels (Adlersberg and Eisler 1959), higher triglyceride but not cholesterol (Albrink et al. 1963, Billimoria 1976), hyperlipidemia only in young diabetics (New et al. 1963), only in older diabetics (Santen et al. 1972), only in diabetics with large vessel disease (Reinheimer et al. 1967), or only in those with small vessel disease (Kissebah 1975).

High density lipoprotein cholesterol (HDL-C) is inversely and independently predictive of ischemic heart disease in nondiabetics (Heiss 1980). Juvenile or insulin-dependent diabetics generally have high or normal levels of HDL-C, although in some studies HDL-C levels are inversely related to the degree of glycemia. There is no consensus about HDL-C levels in adults with noninsulin-dependent diabetes (Nikkila 1981). Population-based studies in Framingham (Gordon et al. 1977) and Rancho Bernardo (Barrett-Connor et al. 1983) both found that HDL-C levels were lower in adult diabetic women compared to nondiabetic women, but only in Rancho Bernardo, where differences also persisted after adjusting for covariates of HDL, were significant differences seen in diabetic versus nondiabetic men. However, a 9-year study of diabetic men in Rancho Bernardo showed that the HDL-C level was not superior to total plasma cholesterol in predicting ischemic heart disease death in diabetics (Barrett-Connor et al. 1985). Among clinic patients, no significant differences in HDL-C levels have been found between diabetics and untreated adult diabetics (Ballantyne et al. 1977, Durrington 1980), or lower HDL-C levels have been found only in drug-treated diabetics (Calvert et al. 1978, Kennedy et al. 1978) or diet-treated diabetics (Stanton 1978) (Table 17). A recent comprehensive review documents the lack of correlation between HDL-C and blood glucose or glycosylated hemoglobin in most studies of insulin-dependent and noninsulin-dependent diabetics (Nikkila 1984).

Blood Pressure

As reviewed in Chapter XVII of this volume, most studies of juvenile or adult diabetics have shown a higher mean blood pressure and/or more categorical hypertension in diabetics compared to nondiabetics, and have shown that diabetics with high blood pressure have a greater risk of cardiovascular mortality than diabetics with normal blood pressure. The contribution of blood pressure to cardiac death appears to be similar in diabetics and nondiabetics. The proportion of diabetics reporting physician-diagnosed high blood pressure was higher than the proportion in persons with normal glucose tolerance in the United States in 1976-80 (Table 18).

Cigarette Smoking

Cigarette smoking is a major risk factor for ischemic heart disease. In some populations, diabetics smoke more, and in other populations less, compared to nondiabetics. In the United States in 1976-80, there was little difference among diagnosed diabetics, undiagnosed diabetics, or persons with normal glucose tolerance in the number of cigarettes smoked per day (Table 18). In Rancho Bernardo, diabetic men were significantly less likely to be current smokers than diabetic women, but the percent currently smoking was not significantly different from that in nondiabetic men and women (Barrett-Connor and Wingard 1983). In a Washington County, Maryland survey, cigarette smoking habits did not differ between diabetics and age- and sex-matched nondiabetics (Dupree and Meyer 1980). Nilsen and Persson (1972) reported significantly more smoking in male insulin-dependent diabetics compared to nondiabetics. In the Radcliffe (England) Infirmary, there were significantly fewer male than female current smokers among patients who had diabetes for more than 20 years (Armstrong and Doll 1975). Diabetic patients of both sexes in Warsaw, Poland were less likely to be current smokers than a representative sample of the general population, although male insulin-treated diabetics were more likely to be current smokers than the whole male diabetic group (Czyzyk and Krolewski 1976). Diabetic men in the Whitehall, England survey did not differ significantly from the general population with regard to cigarette smoking (Reid et al. 1974).

TABLE 17. *High density lipoprotein (HDL) levels in diabetics and nondiabetics*

			Insulin-Dependent or Treated			Noninsulin-Dependent			Control Nondiabetics			
Reference	Method*	Sex	HDL	N	Age	HDL	N	Age	HDL	N	Age	Statistical Significance
a	Phos	M,F	1.02	85[cc]	48	.87[aa] 1.01[bb]	22 15	58 53	1.08 1.09	351 28	23[cc] 71[dd]	Sulf. vs. other therapy, p<.05
b	U-C	M	1.44	20	43				1.21		45	N.S.
		F	1.90	25	38				1.77		41	N.S.
c	Hep	M	1.74	41	--	1.24	45	--	1.42	37	--	Insulin vs. control "significant" in M and F
		F	2.20	38	--	1.71	45	--	1.75	35	--	
d	Hep	M	1.27	29	31				1.15	172	39	N.S.
		F	1.47	20	31				1.42	86	39	N.S.
e	Hep	M	1.51	45					1.40	61	41	p <.02
		F	1.63	49	45				1.69	37	44	N.S.
f	Hep	M,F	1.45	28	10				1.02	25	10	"Signif higher"
g	Phos	M,F	1.60	73	67				1.71	12	66	N.S.
h	U-C	M	1.47[ee] 1.29[ff] 0.98[gg]	56	12				1.37	19	14	Poor vs. good control or normal, p <.001
		F	1.34[ee] 1.24[ff] 1.06[gg]	50	16				1.32	17	15	Poor vs. good control or normal, p <.001
i	U-C	M	1.42	41	48				1.23	42	50	p = .05
		F	1.78	36	52				1.61	31	52	N.S.
j	U-C	M	1.49	26	45	1.33	21	50	1.23	39	47	IDD vs. control, p <.01
		F	1.94	31	47	1.57	14	49	1.64	31	49	IDD vs. control, p <.01
k,l	U-C	M	1.53	84	47				1.29	91	46	p <.001
		F	1.76	86	47				1.50	49	46	p <.001
m	Hep	M	1.29	44	9-18				1.19	20	9-18	N.S.
		F	1.30	43	9-18				1.27	22	9-18	N.S.
n	Hep	M	1.1	11	2-12				1.2	33		N.S.
		F	0.9	8	2-12				1.2	31		N.S.
o	Hep	M,F	1.5	106	55	1.3	67					p <.005
p	Hep	M,F	1.75	14	33	1.53	13	44	1.46	12		Insulin vs. control, p <.01
q	Hep	M,F	1.22[hh] 1.24[ii] 1.16[jj]	123	15				1.26	74	16	P-value trend N.S.
r	Hep	M	1.29	34	--	1.10	48	--				p <.02
		F	1.55	34	--	1.41	45	--				N.S.

*Phos = phosphotungstate Mg Cl_2; U-C = ultracentrifuge; Hep = heparin manganese chloride

(Continued)

TABLE 17. (Continued)

[aa]Sulfonylurea therapy
[bb]Diet therapy only
[cc]Servicemen only
[dd]Elderly persons
[ee]Good control
[ff]Fair control
[gg]Poor control
[hh]HbA1 <13
[ii]HbA1 13-15
[jj]HbA1 >15

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TABLE 18. *Percent of persons who report the presence of conditions that are cardiovascular risk factors, United States, 1976-80*

Reported Condition and Glucose Tolerance Status*	Age (Years)				
	20-74	20-44	45-54	55-64	65-74
High blood pressure					
Diagnosed diabetes	56.2	40.0	54.7	62.9	62.9
Undiagnosed diabetes	50.0	31.2	51.4	50.5	58.9
IGT	42.4	18.8	36.7	58.7	56.8
Normal	21.4	14.1	27.0	31.7	40.4
Hardening of the arteries					
Diagnosed diabetes	11.2	0	11.2	10.1	19.9
Undiagnosed diabetes	1.9	0	0	0.9	5.6
IGT	6.7	0	0	13.9	14.4
Normal	1.8	0.2	2.8	2.9	8.6
Smoke 1-10 cigarettes per day					
Diagnosed diabetes	6.0	5.9	5.8	6.9	4.4
Undiagnosed diabetes	8.9	16.4	7.8	9.2	5.4
IGT	6.0	7.5	4.0	5.7	7.1
Normal	8.8	9.6	7.3	7.2	9.6
Smoke 11-20 cigarettes per day					
Diagnosed diabetes	9.9	18.0	9.3	8.7	6.5
Undiagnosed diabetes	11.0	0	27.7	8.8	5.1
IGT	15.2	18.2	10.6	19.5	12.9
Normal	16.0	17.7	17.0	12.6	8.9
Smoke 21+ cigarettes per day					
Diagnosed diabetes	9.3	15.5	14.8	6.9	3.9
Undiagnosed diabetes	11.2	12.9	22.7	5.5	6.3
IGT	8.0	10.6	13.5	0	7.7
Normal	9.4	9.9	12.3	9.0	1.7
Physical activity - very active					
Diagnosed diabetes	30.3	41.9	37.3	26.8	20.1
Undiagnosed diabetes	36.6	54.9	29.7	35.4	34.0
IGT	32.4	35.9	35.1	26.1	32.3
Normal	41.4	42.7	42.9	39.7	33.0
Physical activity - moderately active					
Diagnosed diabetes	48.1	48.0	41.6	53.2	48.7
Undiagnosed diabetes	50.7	41.8	49.5	51.9	55.4
IGT	53.9	50.7	52.0	57.0	56.1
Normal	50.4	50.7	46.1	51.5	54.9
Little physical activity					
Diagnosed diabetes	21.6	10.1	21.1	20.0	31.2
Undiagnosed diabetes	12.7	3.6	20.8	12.8	10.6
IGT	13.8	13.4	12.9	16.8	11.6
Normal	8.2	6.7	11.0	8.8	12.0

*National Diabetes Data Group criteria applied to the results of 2-hour, 75-gram oral glucose tolerance tests; IGT=impaired glucose tolerance.

SOURCE: Harris, MI, National Diabetes Data Group, data from the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

Obesity and Physical Activity

In the United States in 1976-80 more than half of diagnosed diabetics were 20 percent or more above ideal body weight (Table 19). Similar percents of persons with no medical history of diabetes but with oral glucose tolerance tests that indicate they are diabetic or have impaired glucose tolerance were obese, whereas only 34 percent of persons with normal glucose tolerance were 20 percent or more above ideal body weight. Little difference among these diabetes diagnostic groups was found for reported levels of physical activity, although diagnosed diabetics may have a higher proportion of persons with little physical activity (Table 18).

TABLE 19. *Percent of persons ages 20-74 years with percent desirable weight of 120 or greater, United States, 1976-80*

Diabetes Status*	Percent with PDW ≥120
Medical history of diabetes	56
No medical history, diabetic OGTT	63
No medical history, impaired glucose tolerance	53
No medical history, normal OGTT	34

*National Diabetes Data Group criteria applied to the results of 2-hour, 75-gram oral glucose tolerance test

SOURCE: Hadden, WC, and MI Harris. Prevalence of diagnosed diabetes, undiagnosed diabetes, and impaired glucose tolerance. NCHS Series 11 in preparation.

Platelets

Most studies have indicated that platelet adhesiveness is increased in diabetics of different types with and without vascular disease (Table 20). Platelets from diabetics also have increased sensitivity to aggregating agents, particularly in patients with macro- or microvascular disease (Table 21). An excellent review of these and other hemostatic abnormalities in diabetics has been published (Greaves and Preston 1984). It remains to be determined whether these or other abnormalities of the coagulation system in diabetics play a role in their excess risk of ischemic heart disease.

TABLE 20. *Platelet adhesiveness in diabetes mellitus*

		Therapy		Vascular Disease		
Investigator	Year of Publication	No Insulin	Insulin	Micro	Macro	Results
Odegaard	1964	0	+	0	0	Positive in all types
Shaw	1967	+	+	0	0	Positive in all types
Valdorf-Hansen	1967	−	+	+	0	Positive--microvasc. dis.
Bielawiec	1970	+	+	+	+	Positive in all types
Badawi	1970	+	+	−	+	Positive in all types
Heath	1971	−	+	+	+	Negative
Hellem	1971	+	+	+	+	Positive in all types
Mayne	1971	−	+	+	+	Positive in all types
Mason	1972	−	−	0	0	Positive in all types
Seth	1973	+	0	0	0	Positive in all types
Bedi	1976	+	+	0	0	Positive in all types Improved with therapy
Fuller	1979	+	+	+	+	Positive in all types

Key: 0 = absent or not studied; + = present; − = no information

SOURCE: Colwell, JA, M Lopes-Virella, and PV Halushka. Pathogenesis of atherosclerosis in diabetes mellitus. Diabetes Care 4:124, 1981.

TABLE 21. *Platelet aggregation in diabetes mellitus*

		Therapy		Vascular Disease				Results			
Investigator	Year of Publication	No Ins.	Ins.	None	Micro	Macro	Agent*	Positive All Types	Positive Micro Only	Negative	Remarks
Breddin	1965	-	-	-	-		**	+			70% pos. > 40 40% pos. < 40
Szirtes	1969	-	-	+	+	+	**	+			
Rathbone	1970	+	+	+	+	+	**		+		
Heath	1971	+	+	+	+	0	ADP		+		
Hassanein	1972	+	+	+	+	0	ADP	+			Inc. by insulin
Leone	1974	+	+	+	+	+	ADP	+	+		Vasc. dis. > non vasc. dis.
Davis	1974 1978	+	+	+	+	+	ADP			+	Men, cor. art. dis.
Passa	1974	0	+	+	+	0	ADP		+		Prolif. retinop.
Sagel	1975	+	+	+	+	+	ADP, Epi., Coll.	+			
Bensoussan	1975	0	+	+	+	+	ADP		+		
O'Malley	1975	-	-	+	+	0	ADP, Epi.		+		Neuropathy pos.
Colwell	1976 1977	+	+	+	+	+	ADP, Epi., AA	+			
Fleischman	1976	+	+	+	0	0	ADP***	+			Improved by linoleate
Breddin	1976	+	+	+	+	+	None**	+			
Matsuo	1977	+	+	+	+	+	ADP	+			Retinop. > no retinop.
Peterson	1977	0	+	+	+	0	Epi.	+			Improved by insulin
Halushka	1977	0	+	+	+	0	ADP, Epi., Coll., AA	+			Increased iPGE$_2$
Petersen	1978	0	+	+	+	+	ADP, Epi.			+	
Creter	1978	0	+	0	+	0	ADP, Epi. AA		+		ADP: neg.
Stuart	1979	0	+	+	+	0	Thrombin	+			Increased MDA
Corbella	1979	0	+	+	0	0	ADP, Epi.			+	
Khosla	1979	0	+	0	+	0	ADP, Epi.		+		
Gensini	1979	+	+	+	+	+	Thrombin, AA	+			Increased MDA
Klaff	1980						ADP	+			Improved by sulfonylureas
Lecrubier	1980	+	+	+	+	0	ADP, Coll.	+			Increased with age

Key: 0 = absent or not studied; + = present; - = no information

*ADP = adenosine 5'-diphosphate; Epi. = epinephrine; Coll. = collagen; AA = arachidonic acid

**Rotating disc on Chandler loop. No aggregating agent.

***Filtration procedure. Aggregometer used in all other studies.

SOURCE: Colwell, JA, M Lopes-Virella, and PV Halushka. Pathogenesis of atherosclerosis in diabetes. Diabetes Care 4:125,1981.

Clustering and Interaction of Cardiovascular Risk Factors in Diabetics

None of the conventional heart disease risk factors singly or in combination completely explains the excess risk of ischemic heart disease in diabetics, or why diabetes increases the risk in women more significantly than in men. Most studies have shown that the risk of ischemic heart disease associated with cardiovascular risk factors is similar for diabetics and nondiabetics (Dupree and Meyer 1980, Fuller et al. 1980, Kannel and McGee 1979b, Ostrander et al. 1965). These attempts to show an interaction or synergistic effect of diabetes and heart disease risk factors are based on a comparison of the relative risk of heart disease associated with a factor such as cigarette smoking in diabetics versus nondiabetics. Interaction has not been demonstrated. In contrast, analysis of the Rancho Bernardo population shows a strong interaction effect for diabetes and cigarette smoking, such that 65 percent of cardiovascular deaths in diabetics could be attributed to smoking (Suarez and Barrett-Connor 1984). No significant interaction was found for total plasma cholesterol, triglyceride, or systolic blood pressure. In this population, diabetic adults with one risk factor (cholesterol, blood pressure, or cigarette smoking at or above the 70th or 90th percentile) were more likely than nondiabetics to have high levels of other risk factors. These differences persisted after controlling for obesity, and clustering of cardiovascular risk factors was more marked in women than in men in Rancho Bernardo (Wingard et al. 1983).

MORTALITY

In the United States, based on death certificate data, diabetes is currently the seventh leading underlying cause of death. About 62 percent of these diabetes deaths involved ischemic heart disease in 1978, the most recent year for which multiple cause of death analyses are available (Table 22). In 54 percent of deaths in which diabetes was a contributing cause of death in 1978, ischemic heart disease was the underlying cause, implicating diabetes in 8 percent of all ischemic heart disease deaths. The deficiencies of death certificate data are well known, and are particularly problematical for analyses of deaths from cardiovascular diseases and diabetes. Somewhat better data on deaths attributable to heart disease in diabetics are derived from clinical studies, usually retrospectively identified groups of patients, and from prospective studies of whole populations.

Mortality in IDDM

Death certificate data. Among death certificates in the United States in 1978 for persons aged 0-34 years at death and in which diabetes was the underlying cause of death, 15 percent mentioned ischemic heart disease. For certificates where diabetes was a contributing cause of death, 33 percent were coded to a cardiovascular condition, with 17 percent being coded to ischemic heart disease (Table 22). Analysis of death certificates from Washington State showed that the mortality rate from medical causes among diabetics less than 45 years of age at death was eight times the death rate for the general population of equivalent age; deaths attributed to myocardial infarction or atherosclerotic heart disease accounted for 2.5 percent of deaths for diabetics ages 0 to 24 years, 15 percent for those ages 25 to 34, and 39 percent for those ages 35 to 44 (Connell and Louden 1983).

TABLE 22. *Cardiovascular conditions associated with diabetes on death certificates, United States, 1978*

	ICD Number	Age At Death (Years) All	0-34	35-64	65+
Diabetes as Underlying Cause (Conditions Below as Contributing Causes)		Average Number of Conditions per Certificate			
Cardiovascular diseases	390-458	1.43	0.61	1.28	1.50
Hypertensive diseases	400-404	0.04	0.04	0.05	0.04
Ischemic heart disease	410-414	0.62	0.15	0.61	0.63
Other forms of heart disease	420-429	0.30	0.29	0.31	0.30
Cardiac arrest NOS	427.2	0.13	0.19	0.15	0.12
Cerebrovascular diseases	430-438	0.24	0.08	0.15	0.28
Diseases of arteries, arterioles, capillaries	440-458	0.22	0.06	0.17	0.24
Number of death certificates	-	33,841	754	8,730	24,372
Underlying Cause of Death (Diabetes as Contributing Cause)		Percent of Mentions of Diabetes as Contributing Cause of Death			
Cardiovascular diseases	390-458	75.6	33.2	71.4	77.0
Hypertensive diseases	400-404	1.6	0.2	1.5	1.6
Ischemic heart disease	410-414	54.2	17.4	55.5	47.1
Other forms of heart disease	420-429	2.4	1.8	3.0	2.2
Cardiac arrest NOS	427.2	0.6	1.3	1.0	0.5
Cerebrovascular diseases	430-438	13.3	4.0	8.1	14.8
Diseases of arteries, arterioles, capillaries	440-458	3.6	0.9	2.7	3.8
All other diseases	-	24.4	66.8	28.6	23.0
Total	-	100.0	100.0	100.0	100.0
Number of death certificates	-	96,847	455	21,221	75,156

SOURCE: Harris, MI, National Diabetes Data Group. From multiple cause of death data filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

Studies on diabetic patients. Almost all of the studies shown in Table 23 on juvenile-onset (presumably insulin-dependent) diabetics are based on clinical patients whose representativeness of all insulin-dependent diabetics ranges from "available for study" cases (Kerr et al. 1952) to all known insulin-dependent cases in a hospital registry (Dorman et al. 1984). Despite difficulties in comparing these studies, a reasonable conclusion from the table is that heart disease is a relatively rare cause of death in the first 30 years of insulin-dependent diabetes. Total mortality, however, is high: four of the studies (Christlieb 1981, Deckert 1978, Dorman 1984, Knowles 1970) show that approximately 20 percent of insulin-dependent diabetics are dead within 25 years after onset of their disease. Studies with a followup duration of fewer than 40 years (when the diabetics are less than 40 years of age) show that heart disease accounts for 10 percent of all deaths; in studies with a followup of 40 or more years (when the diabetics are 40+ years of age), heart disease accounts for 30 percent of deaths. The small contribution of heart disease to early mortality and its increasing importance as age (and duration of diabetes) increases are further shown in Table 24 and Figure 1, based on recent data from the large Pittsburgh cohort. Data on deaths occurring in 1956-68 in Joslin Clinic patients are shown in Figure 2; those patients with onset at ages less than 20 years were probably IDDM.

TABLE 23. *Mortality attributed to all causes and to heart disease in insulin-dependent, juvenile-onset diabetics*

Reference	Location	Number of Diabetics Studied	Age at Onset of Diabetes (Year of Onset)	Number of Years Studied	Percent Dying from All Causes	Percent of All Deaths Attributed to Heart Disease*
a	Toronto, Canada	81	<16	Mean 15	5	25
b	Detroit	150	<15	Mean 14	7	0
c	Cincinnati	147	<16	Median 19	21	29
d	Boston	370	<15	40+	68	31
e	Warwickshire, U.K.	45	<12	10+	16	0
f	Copenhagen, Denmark	289	<31 (before 1933)	40+	60	26
g	Paris, France	226	<16 (1949-60)	16-26	11	0
h	Boston	65	<21 (1938-40)	25	54	49
i	Pittsburgh	1,894	<17 (1950-81)	Mean 13	9	9

*Myocardial infarction, coronary artery disease, or ischemic heart disease.

(Continued)

TABLE 23. (Continued)

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TABLE 24. *Percent distribution of causes of death, by age at death, of IDDM patients who died among 1,894 IDDMs diagnosed at age 0-16 years, Pittsburgh, 1950-81*

	Age at Death (Years)				
Cause of Death	0-9 (N=19)	10-19 (N=24)	20-29 (N=77)	30+ (N=37)	All Ages (N=157)
Not IDDM-related	25	34.8	18.2	13.5	20.3
Acute complications	75	47.8	2.6	0	17.8
Renal disease	-	4.3	54.5	48.6	38.9
Heart disease	-	4.3	6.5	24.3	9.6
Other IDDM complications	-	8.7	18.2	13.5	13.4

SOURCE: Dorman, J, RE LaPorte, LH Kuller, K Cruickshanks, TJ Orchard, DK Wagener, DJ Becker, D Cavender, and AL Drash. The Pittsburgh IDDM morbidity and mortality study. Diabetes 33:271-78, 1984.

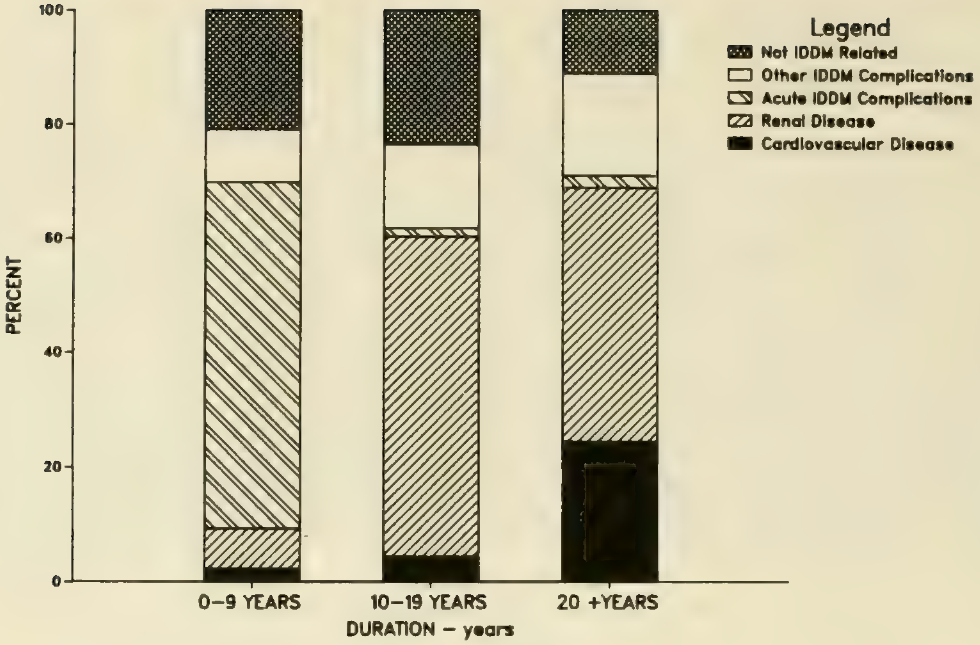

FIGURE 1. *Distribution of cause of death by duration of IDDM, Pittsburgh, Pennsylvania 1950-81*

SOURCE: Dorman, JS, and T Orchard, personal communication.

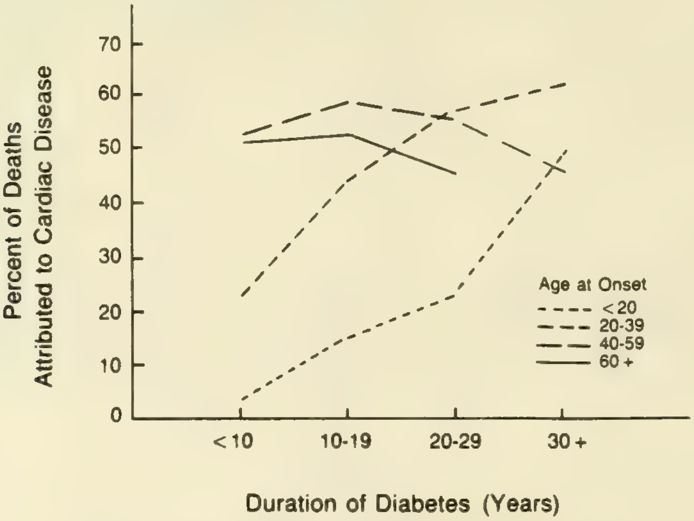

FIGURE 2. *Percent of deaths during 1956-68 attributed to cardiac disease among diabetic patients, by age at onset and duration of diabetes, Joslin Clinic*

SOURCE: Marks, HH, and LP Krall. Onset, course, prognosis, and mortality in diabetes mellitus. In: Marble, A, P White, et al., eds. Joslin's Diabetes Mellitus. 11th ed. Philadelphia: Lea and Febiger, 1971.

The cardiovascular mortality rate (including cerebrovascular disease) for whites in the Pittsburgh insulin-dependent diabetes cohort was 24 times that of the 1970 United States population rate for ages 25 to 29 years, and 32 times the 1970 United States rate for ages 30 to 35 years (Dorman 1985). The number of cardiovascular deaths in this young population was more than 11 times greater than what would be expected among nondiabetic individuals of the same age (Dorman et al. 1984).

Thus, cardiovascular mortality in insulin-dependent diabetics is considerably greater than the general population, although the proportion of total mortality it accounts for in younger-onset diabetics is relatively small.

Mortality in NIDDM

Death certificate data. Among death certificates in the United States in 1978 for persons ages 35 years or older at death and in which diabetes was the underlying cause of death, about 62 percent mentioned ischemic heart as a contributing cause of death. For certificates in which diabetes was a contributing cause of death, about three-fourths involved a cardiovascular disease and 50 percent were coded to ischemic heart disease (Table 22).

Studies on diabetic patients. Among Joslin Clinic patients ages 40 years or older at onset of diabetes, about half of deaths occurring between 1956-68 were due to cardiac disease; this proportion was similar for persons whose durations of diabetes ranged from less than 10 years to more than 30 years (Figure 2). Among diabetics in Rochester, 39 percent of deaths occurring between 1965-74 were due to coronary heart disease (Ochi et al. 1985). Forty-two percent of deaths were attributed to arteriosclerotic heart disease in diabetic life insurance applicants during 1951-71 (Goodkin 1975). Studies of mortality in older diabetics, most of whom probably have noninsulin-dependent diabetes, also derive from prospective population-based studies of risk factors for cardiovascular disease. Four recent studies of males in the United States and England document an age-adjusted relative risk in diabetics compared to nondiabetics of 1.4 to 2.3 for deaths from all causes and 2.3 to 5.6 for deaths from ischemic heart disease (Table 25). Among men ages 40-54, the risk was 6-8 times greater for diabetic males in one study (Table 26). The four United States population-based studies that include women all show a higher relative risk of death from ischemic heart disease for female diabetics versus female nondiabetics, a risk that appears to persist after adjusting for associated risk factors such as hypertension, hyperlipidemia, and cigarette smoking (Table 21). As Jarrett (1977) has pointed out, the greater mortality from coronary heart disease in diabetics could reflect an increased rate of death among diabetics with heart disease versus nondiabetics (case fatality) rather than an excess of cases of heart disease among diabetics.

TABLE 25. *Diabetes and ischemic heart disease mortality in middle-aged men*

			Relative Risks* of Death in Diabetics Versus Nondiabetics Due to	
Reference	Study and Diabetes Criteria	Number of Men Studied	All Causes	Ischemic Heart Disease
a	Chicago People's Gas Company Study; 15-year mortality; criteria for diabetes was medical history of diabetes.			
	Known diabetes	21	1.4	2.3
	No diabetes	1,299		
a	Chicago Heart Association Detection Project in Industry; 5-year mortality; criteria for diabetes was medical history of diabetes.			
	Known diabetes	263	2.0	3.1
	No diabetes	7,033		
b	Whitehall, England Study; 7.5-year mortality; diabetes criteria was medical history for known diabetes, capillary glucose ≥200 at 2 hrs. after 50-gm glucose for new diabetes.			
	New diabetes	55	2.3	5.6
	Known diabetes			
	Insulin-dependent	46	1.8	2.3
	Non-insulin-dependent	119	2.2	2.4
	No diabetes	16,803		
c	Bedford, England Study; 10-year mortality; diabetes criteria for new diabetes was no medical history plus glycosuria plus capillary glucose ≥200 at 2 hrs. after 50-gm glucose.			
	New diabetes	102	2.0	2.2
	No diabetes	208		

*Age-adjusted relative risks or relative odds

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c. Jarrett, RJ, P McCartney, and H Keen. The Bedford Survey: Ten year mortality rates in newly diagnosed diabetics, borderline diabetics and normoglycaemic controls and risk indices for coronary heart disease in borderline diabetics. Diabetologia 22:79-84, 1982, and RJ Jarrett, personal communication.

TABLE 26. *Sex differences in ischemic heart disease mortality among diabetics versus nondiabetics*

Reference	Study Location	Years of Study	Age (Years)	Number		Diabetics Estimated Relative Risk[1]		Diabetics Multiply Adjusted Risk[2]	
				Diabetics	Deaths	Male	Female	Male	Female
a	Rancho Bernardo, CA[3]	1972-80	40-79	343	24	2.5	3.4	2.4	3.5
b	Framingham, MA[4]	1948-68	45-74	-	-	2.1	4.9	1.7	3.3
c	Evans County, GA[5]	1967-74	22+	112	7	1.2	2.7	1.0	2.8
d	Tecumseh, MI[6]	1959-78	40-54	37	11	6.1	6.5	7.9	7.7
			55-69	51	11	1.9	1.0	2.6	0.6
			70+	26	14	1.3	2.6	1.9	5.3

1. Evans County risks are not age-adjusted; Tecumseh risks are ratios of age-specific observed ratios calculated using person-years; all others are age-adjusted.

2. Multiply-adjusted risks all control for blood pressure, cholesterol, and cigarette smoking, with other covariates in some studies. Rancho Bernardo and Tecumseh used the Cox standardized risk ratio; Framingham, relative risks; and Evans County, a standardized mortality ratio.

3. Diagnostic criteria for diabetes: FPG ≥ 140 mg/dl and/or medical history of diabetes.

4. Diagnostic criteria for diabetes: Casual blood glucose ≥ 150 mg/dl on two successive visits and/or history of treatment with oral hypoglycemic agents or insulin.

5. Diagnostic criteria for diabetes: "Glucose tolerance test ≥ 200 mg/dl," or fasting plasma glucose ≥ 120 mg/dl, or casual blood glucose ≥ 160 mg/dl and/or history of treatment with oral hypoglycemic agents or insulin.

6. Diagnostic criteria for diabetes: Medical history of diabetes treated with oral hypoglycemic agents or insulin.

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d. Butler, WJ, LD Osterander, WJ Carman, and DE Lamphlear. Mortality from coronary heart disease in the Tecumseh Study. Am J Epidemiol 121:541-47, 1985.

Survival

In Rochester during 1945-69, diabetics with clinical manifestations of ischemic heart disease had a modest reduction in survival after angina pectoris (Figure 3). However, there were striking decreases in survival during the first year after a heart attack or congestive heart failure in diabetics compared to the survival of the general population of the Northwest Central states. These data do not indicate whether diabetics with manifest heart disease have a poorer prognosis than nondiabetics with manifest heart disease, as the expected survival in Figure 3 is based on deaths due to all causes, not just heart disease. Extensive attempts to answer this question are based on studies of mortality in patients after myocardial infarction. Among 4,108 myocardial infarction cases reported in the literature up to 1950, including 265 with diabetes, no significant

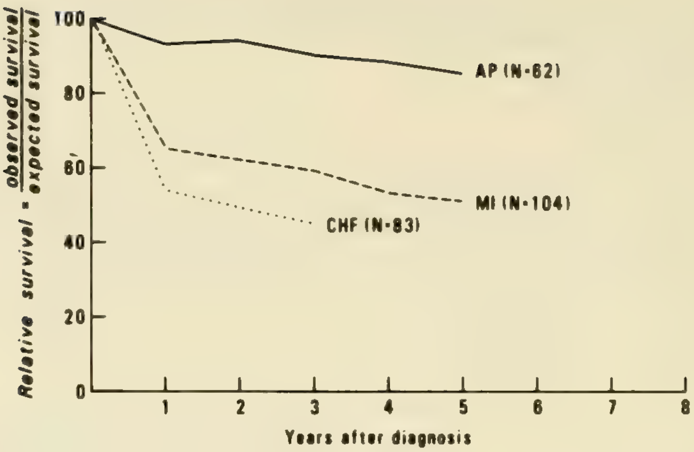

FIGURE 3. *Relative survival after the first diagnosis of angina pectoris (AP), myocardial infarction (MI), or congestive heart failure (CHF) in diabetics in Rochester, Minnesota, 1945-69. Expected survival is derived from the 1960 age-sex distribution and death rates due to all causes of the Northwest Central States*

SOURCE: Palumbo, PJ, LR Elveback, and DC Connolly. Coronary heart disease and congestive heart failure in the diabetic: Epidemiological aspects. The Rochester Diabetes Project. In: Scott, RC, ed. Clinical Cardiology and Diabetes. Vol. 1. Mount Kisco, NY: Futura, 1981. p. 25.

difference was found in early mortality due to myocardial infarction in diabetics versus nondiabetics (Doscher and Poindexter 1950). In contrast, a large number of more recent studies of patients generally show higher death rates in diabetics than in nondiabetics (Table 27).

The wide variations in early mortality in different studies, which may reflect differences in severity or treatment of myocardial infarction, illustrate the inappropriateness of nonconcurrent comparison groups. The studies with concurrent controls are rarely age-adjusted or sex-specific, although some studies suggest a much poorer prognosis after myocardial infarction in female versus male diabetics. In most reports, the criteria for the diagnosis of diabetes are not specified, and it is not clear whether diabetes that was first diagnosed during the hospitalization for the heart attack was included.

TABLE 27. *Early mortality after myocardial infarction in diabetics who survive to hospitalization*

				Percent Mortality (Number Followed)			
				First Infarctions		All Infarctions	
Reference	Year of Publ.	Source of Population	Duration of Follow-up	Diabetics	Comparison Group	Diabetics	Comparison Group*
a	1952	Hospital				31 (39)	
b	1954	Hospital ECG files, U.S.	60 days			20 (63)	21 (398)
c	1956	Hospital, U.S.	60 days	58 (83)		61 (160)	
d	1957	Hospital, U.K.	60 days			51 (37)	23 (431)
e	1960	Hospital, Finland	21 days	22 (9) men 44 (16) women	22 (276) 27 (75)		
f	1960	Hospital, Finland	"early"	19 (49) men 34 (73) women	19 32		
g	1961	Hospital, U.K.	40 days			30 (33) men 37 (35) women	26 (241) 19 (84)
h	1961	Hospital, Sweden	28 days	46 (59) men 57 (69) women	34 34		
i	1963	Hospital, U.S.	60 days	13 (23)	16 (133)	26 (38)	20 (218)
j	1965	Hospital, U.S.	60 days	31 (83) men 44 (117) women	42 (258) 52 (27)		
k	1973	Hospital, Sweden	Duration of hospitalization	29 (7) women		5 (40) women	
l	1974	CCU, U.K.	Duration of hospitalization			35 (184)	18 (1,804)
m	1976	CCU, U.K.	Duration of hospitalization			24 (99)	19
n	1976	Hospital, Denmark	28 days			30 (37)	33
o	1976	Nursing home, Israel	30 days			39 (39)	39 (93)
p	1977	CCU, South Africa	Duration of hospitalization	28 (67)	13 (595)	28 (89)	14 (793)
q	1978	Hospital, Malta	"early"			19 (173) men 24 (116) women	13 (540) 19 (116)
r	1980	Hospital, Poland	Duration of hospitalization			36 (154)	19 (154)

*In most studies the comparison group includes diabetics, and data are not matched for sex or adjusted for age differences.

(Continued)

TABLE 27. (Continued)

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Inclusion of diabetics diagnosed after a coronary event requires survival of sufficient duration for diagnosis and could result in an artificially high survival of diabetics (Liebow and Badger 1963). Also, there may be problems when the diagnosis of diabetes follows the cardiac event: the oft-noted excess frequency of glucose intolerance in patients hospitalized for myocardial infarction may reflect in part the transient glucose intolerance associated with any acute illness. Intravenous glucose intolerance has been found to be equally common in patients hospitalized for acute trauma and in patients hospitalized for myocardial infarction (Pearson 1971). More recently, glycosylated hemoglobin levels measured at the time of hospitalization for myocardial infarction have been used to distinguish stress hyperglycemia from the hyperglycemia of diabetes (Hubbard et al. 1983, Oswald et al. 1984). In addition, it is not possible to address the role of Berksonian bias in studies based on hospitalized cases; if patients with less severe infarctions are more likely to be hospitalized because they are known to have diabetes, an artificially high survival of diabetics could result. Alternatively, delayed hospitalization of diabetics with a heart attack could adversely affect outcome. This possibility is supported by reports of a higher frequency of "painless" infarction in diabetics, particularly women (Kuusisto and Sydanmaa 1960, Partamian and Bradley 1965, Margolis et al. 1973).

Data on long-term survivorship of diabetics after myocardial infarction are more limited. In the only population-based study, conducted in Rochester, 51 percent of diabetics survived for 5 years (Palumbo et al. 1981). Two clinic-based studies of diabetics found a 51 percent 1-year survivorship in 285 diabetics (Soler et al. 1975) and a 30 percent 2-year survivorship in diabetics compared with 66 percent in those without previously known diabetes (Badger and Liebow 1965). The 5-year survival of diabetic adults who lived at least 2 months after myocardial infarction ranged from 25 to 43 percent in three older studies; this was considerably less than survival in nondiabetics, which usually exceeded 60 percent (Table 28). In the 9-year followup of 666 patients from the Perth Coronary Register who were alive 28 days after myocardial infarction, the relative risk of death from any cause in those with a history of diabetes (n=42) was 2.1 times that in those without such a history (p less than .0001). After controlling for other potentially prognostic variables, the relative risk of an ischemic heart disease death for diabetics was 1.73 (p less than .05) (Martin et al. 1983).

TABLE 28. *Five-year survival of diabetic patients who lived at least 2 months after a myocardial infarction*

Reference	Year of Publication	Number of Persons Studied	Percent Survival
a	1954	42 diabetics	43
b	1956	40 diabetics	40
c	1965	127 initial attacks in diabetics	38
		24 subsequent attacks in diabetics	25
		Nondiabetics	>60

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As noted, if patients are to be studied after a myocardial infarction, they must survive to hospitalization; if diabetics with a heart attack are more likely to die prior to hospitalization, those who survive may represent a subsample of diabetics with a favored prognosis. Relatively little study has been conducted on the risk of sudden cardiovascular death in diabetics, and the results are conflicting. A retrospective study in Helsinki, Finland, suggested that diabetes mortality involves nonsudden cardiovascular death to a much greater degree than sudden death; in fact, in men, there were fewer known diabetics in the sudden death group than among survivors (Table 29). Similarly, in a small prospective study, 73 Finnish men who had glucose tolerance tests at the end of hospitalization for myocardial infarction had a significantly lower proportion of abnormal tests, and lower mean 1- and 2-hour blood glucose levels in the group with subsequent sudden death, compared to survivors or those with nonsudden death (Kentala and Repo 1982). In contrast, prospective studies from Israel, Framingham, and Rochester all showed a significant excess risk of sudden death in previously diagnosed diabetics (Table 30). A prospective case control study of the San Francisco Kaiser-Permanente patient population found progressively higher plasma glucose levels in relation to the suddenness of death (Table 31).

TABLE 29. *A community study in Helsinki, Finland of the prevalence of diabetes in sudden death versus other comparison groups*

	Patients Experiencing Sudden Death (<1 Hour)		Patients Experiencing Nonsudden Coronary Death		Survivors	
Age (Years)	Number of Patients	Percent with Diabetes*	Number of Patients	Percent with Diabetes*	Number of Patients	Percent with Diabetes*
Men						
-49	36	8.3	28	14.3	150	6.7
50-59	66	9.1	68	14.7	238	10.5
60-65	79	10.1	67	11.9	149	15.4
Total	181	9.4	163	13.5	537	10.8
Women						
-49	3	0	4	50.0	26	0
50-59	16	6.3	16	37.5	78	12.8
60-65	15	26.7	38	31.6	94	10.6
Total	34	14.7	58	34.5	198	10.1

*The diagnosis of diabetes was based on information obtained from the patients or their relatives, with confirmation sought from hospital records.

SOURCE: Adapted from Romo, M. Factors related to sudden death in acute ischemic heart disease. Acta Med Scand [Suppl] 547:9-92, 1972.

TABLE 30. *Estimated relative risk of sudden death in diabetics* versus nondiabetics*

			Relative Risk, Diabetics vs. Nondiabetics		
Reference	Study Characteristics	Sex	Previously Diagnosed Diabetics	Newly Diagnosed Diabetics	All Diabetics
a	Infarction death <1 hour; Israeli civil servants and municipal employees; age 40+, 5-year followup	men	3.6	0.6	--
b	"Sudden death"; Rochester, MN; age 30+ years, >3,000 person-years observation	men	1.8	--	--
		women	3.4	--	--
c	"Sudden death"; Framingham, MA; age 45 to 79 years, 18-year followup	men	--	--	1.4
		women	--	--	1.0

*These studies include both diabetics and persons with impaired glucose tolerance. The diagnostic criteria used were: Israeli--two fasting values ≥110, or one fasting value >130, or one casual >160, or positive history and/or treatment for diabetes; Rochester--two fasting values >110, or 1-hour >180 and 2-hour >140 (lower values for persons <70 years); Framingham--casual value >150, and/or history of treatment with oral agents or insulin.

(Continued)

TABLE 30. (Continued)

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TABLE 31. *Kaiser-Permanente prospective case-control study of sudden death in relation to postchallenge glucose levels*

	Deaths <24 Hours		Deaths <1 Hour		Deaths <1 Minute	
	Cases	Controls	Cases	Controls	Cases	Controls
Mean glucose (mg/dl)	196.0	188.2	198.8	178.6	204.3	172.0
p value	>0.05		<0.01		<0.001	

SOURCE: Friedman, GD, AL Klatsky, and AB Siegiaub. Predictors of sudden cardiac death. Circulation [Suppl IV] 51:164-75, 1975.

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APPENDIX A. *Number and percent of office visits for coronary heart disease (410-413) listed as first, second, or third diagnosis, by other most frequent diagnoses: United States, 1975-76*

Diagnosis and ICDA Code		Coronary Heart Disease Listed as First Diagnosis		Coronary Heart Disease Listed as Second or Third Diagnosis	
		Number of Visits (Thousands)	Percent of Visits	Number of Visits (Thousands)	Percent of Visits
All visits		31,314	100.0	20,887	100.0
Diabetes mellitus	250	2,029	6.5	1,574	7.5
Obesity	277	1,079	3.5	-	-
Cerebrovascular disease	430-438	623	2.0	618	3.0
Bronchitis, emphysema, asthma	490-493	838	2.7	847	4.1
Arthritis and rheumatism, except rheumatic fever	710-718	1,469	4.7	1,344	6.4

SOURCE: Cypress, BK. Office visits for diseases of the circulatory system, NAMCS, 1975-76, National Center for Health Statistics, Vital and Health Statistics Series 13, No. 40, January 1979.

APPENDIX B. *Reported prevalence of certain cardiovascular conditions, United States, 1976*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Arteriosclerosis								
All persons 20 years and over	27.5	114.4	1.9	21.1	24.8	84.8	117.6	189.4
Men	26.7	130.7	2.3	21.7	28.8	106.6	117.1	207.9
Women	28.1	102.1	1.6	20.7	21.1	64.7	117.9	177.1
White	29.2	124.5	1.9	25.6	26.1	90.3	122.0	202.9
Black	15.9	64.2	2.3	0.0	14.1	60.9	77.9	108.7
Heart attack								
All persons 20 years and over	32.7	129.9	4.0	16.5	45.7	130.9	102.4	178.5
Men	41.0	163.5	4.8	26.3	63.7	166.0	130.2	215.2
Women	25.3	104.6	3.2	10.8	29.2	98.6	83.0	154.1
White	33.7	134.7	3.8	17.2	46.2	136.7	104.5	181.1
Black	27.3	104.4	6.3	15.0	42.4	107.6	83.2	153.9
Other heart trouble								
All persons 20 years and over	51.2	166.6	20.6	69.1	57.7	151.2	140.1	227.0
Men	47.9	154.1	19.7	69.0	56.0	136.4	139.3	212.9
Women	54.1	176.0	21.4	69.1	59.1	164.9	140.6	236.4
White	51.5	170.4	20.3	78.3	56.9	157.7	140.6	222.5
Black	52.7	147.1	25.2	29.6	66.4	124.4	139.4	255.7

SOURCE: Drury, TF. Computed by the Division of Epidemiology and Health Promotion from 1976 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

CHAPTER XVII. DIABETES AND HYPERTENSION

Michael J. Horan, M.D.

SUMMARY

In the United States, approximately half of diabetics have a medical history of hypertension, compared to about one-fifth of persons with normal glucose tolerance. The hypertension rate in diabetics is 2 to 3 times the rate in nondiabetics at ages 20 to 44 years, but this differential decreases with age such that, at ages 65 years and older, the rate is only about 50 percent higher. In most studies, hypertension rates are higher in female than male diabetics and in black than white diabetics. Although the majority of hypertensive diabetics are aware of their hypertension, in only about 30-50 percent is blood pressure controlled. Hypertension rates appear not to increase with the duration of diabetes or the degree of glucose control when the effect of age is accounted for. In death certificates, hypertension is implicated in 4.4 percent of deaths coded to diabetes, and diabetes is involved in 10 percent of deaths due to hypertension.

Diabetics can develop essential hypertension, secondary forms of hypertension, systolic hypertension, diabetic-nephropathy-induced hypertension, and supine hypertension with orthostatic hypotension (diabetic autonomic neuropathy superimposed upon hypertension of any etiology). There are no good data to characterize the distribution of these types of hypertension among hypertensive diabetics. In addition, very little is known about the pathogenesis of hypertension of any etiology in diabetics. Lowering blood pressure in diabetics who are hypertensive seems advisable because it can decrease the complications that diabetics experience, including retinal exudates, proteinuria, and renal insufficiency. Also, the impact of blood pressure-lowering interventions on the mortality of diabetics with hypertension appears to be favorable, though not overwhelmingly so.

CLINICAL AND PATHOGENETIC FEATURES OF HYPERTENSION IN DIABETES

There are several types of hypertension in patients with diabetes, although information about their relative distribution is lacking. Essential hypertension can coexist with diabetes, and hypertension secondary to conditions such as coarctation of the

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aorta, primary hyperaldosteronism, pheochromocytoma, Cushing's disease, and renal artery stenosis also occur in diabetics. For reasons that are not entirely clear, systolic hypertension occurs with higher frequency in diabetics. This may be accounted for by the accelerated course of atherosclerosis experienced by diabetics, which may result in decreased vascular distensibility. If normal cardiac output is maintained, these atherosclerotic blood vessels may exhibit an exaggerated rise in systolic bood pressure.

Hypertension induced by diabetic nephropathy is the most distinctive kind of hypertension experienced by the diabetic. The syndrome consists of edema, proteinuria, compromised renal function, and hypertension, and the pathologic lesion most often associated with this syndrome is diffuse glomerular sclerosis. The pathophysiology of this disturbance is complex and only poorly understood, but involves complicated interactions between the renin-angiotensin-aldosterone system and the sympathetic nervous system.

Finally, in the diabetic patient who has developed the complication of autonomic neuropathy combined with hypertension of any etiology, the result is supine hypertension with orthostatic hypotension.

There is a paucity of detailed data on pathogenetic mechanisms that explain the development of hypertension in patients with diabetes. Information is only anecdotal about the roles of hormones, the central nervous system, and the renin-angiotensin-aldosterone system in hypertension in diabetics. In the classic form of diabetic-nephropathy-induced hypertension, most data suggest that this is a volume-expanded, low-renin type of hypertension.

METHODOLOGIC PROBLEMS IN THE STUDY OF HYPERTENSION AND DIABETES

Determining the relationship between hypertension and diabetes has never been a straightforward proposition. Although arterial hypertension appears to be a relatively common problem among diabetics, data from well-designed and well-controlled studies that could shed light on the interaction between these two diseases are not plentiful. Studies can be criticized for their definitions of diabetes and hypertension, inappropriate comparison populations, different techniques of blood pressure measurement under variable conditions, and insufficient attention to factors, such as obesity, that influence the occurrence of both diabetes and hypertension.

Studies on hypertension in diabetics are not strictly comparable to one another because of different study populations, experimental design, study conditions, and definitions of diabetes and hypertension. Unless stated otherwise, hypertension in studies included in this chapter was defined as systolic blood pressure greater than 160 mmHg and/or diastolic blood pressure greater than 95 mmHg and/or the taking of antihypertensive medications. The definitions of diabetes were more variable: Typical definitions were a fasting glucose greater than 120 mg/dl and/or 2-hour postprandial glucose greater than 200 mg/dl and/or the taking of glucose-lowering medications.

PREVALENCE OF HYPERTENSION IN DIABETICS

Estimates of the prevalence of hypertension among diabetics range from rates of less than 10 percent to 80 percent in different populations. Examination of the scientific literature, however, indicates the following conflicting findings. When the populations studied are obtained from outpatient clinics (Freedman et al. 1958, Keen et al. 1975) or twin studies (Pyke 1968), there appears to be no increased prevalence of hypertension among diabetics versus nondiabetics. However, community studies and work-site studies comparing subjects with diabetes to age- and sex-matched subjects without diabetes suggest that hypertension, especially systolic hypertension, is more prevalent in diabetics, although the strength of this association is diminished when the effect of obesity on the prevalence of hypertension is included in the analyses (Barrett-Connor et al. 1981, Michigan DPH 1983, Dupree and Meyer 1980, Epstein et al. 1965, Jarrett et al. 1978, Murphy et al. 1982, Pell and D'Alonzo 1970, Stamler et al. 1975).

In the United States in 1976-80, a medical history of hypertension was reported by half of all diabetics, compared to one-fifth of nondiabetic persons (Table 1). In individual age groups, hypertension was 1.6 to 2.8 times more frequent in diagnosed diabetics than in persons with normal glucose tolerance, with the ratio decreasing with age. It was equally frequent among diagnosed and undiagnosed diabetics, and persons with impaired glucose tolerance were intermediate between diabetics and normals.

TABLE 1. *Percent of diabetics and nondiabetics reporting a medical history of high blood pressure, United States, 1976-80*

	Age (Years)				
Glucose Tolerance Status	20-74	20-44	45-54	55-64	65-74
Diagnosed diabetes	56.2	40.0	54.7	62.9	62.9
Undiagnosed diabetes*	50.0	31.2	51.4	50.5	58.9
Impaired glucose tolerance*	42.4	18.8	36.7	58.7	56.8
Normal glucose tolerance*	21.4	14.1	27.0	31.7	40.4
Ratio, diabetics/normal	2.6	2.8	2.0	2.0	1.6

*National Diabetes Data Group criteria applied to the results of a 2-hour, 75-gram oral glucose tolerance test.

SOURCE: Harris, MI, National Diabetes Data Group. Data from the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

The Carolina Health Survey, a statewide probability sampling of the noninstitutionalized adult population ages 18 years and older of South Carolina in 1982, examined the prevalence of hypertension (defined as blood pressure greater than 140/90 mmHg and/or use of antihypertensive medications) among diabetics and nondiabetics. The rate of hypertension among diabetics (61.8 percent) was twice that among nondiabetics (29.3 percent). Among the diabetic population, hypertension was higher in older people compared to the young, in blacks compared to whites, and in males compared to females (Table 2).

In a similar study in Michigan in 1980, a probability sample of adults ages 18 years and older was examined for the prevalence of hypertension. Table 3 shows that diabetics were twice as likely to have hypertension as nondiabetics. As in the United States survey in 1976-80 (Table 1), this ratio decreased with age. Female diabetics were more likely than any other group to have hypertension, and the ratio of female diabetics to female nondiabetics (2.6) was 70 percent greater than the ratio in males. In this population, white and black diabetics had similar rates of hypertension and, for both, the rates were about twice those of nondiabetics.

TABLE 2. *Hypertensive status of diabetics by age, race, and sex, South Carolina, 1982**

	Normotensive Percent (Number)	Hypertensive Percent (Number)	Ratio, % Hypertensive to % Normotensive
Age			
18-49	56.9 (58)	43.1 (54)	0.8
50+	28.0 (52)	72.0 (124)	2.6
Race			
Black	32.7 (37)	67.3 (76)	2.1
Nonblack	41.7 (73)	58.3 (102)	1.4
Sex			
Male	32.7 (34)	67.3 (70)	2.1
Female	41.3 (76)	58.7 (108)	1.4
Total	38.2 (110)	61.8 (178)	1.6

*Diabetes: As reported by the subject. Normotensive: Blood pressure <140/90 mmHg. Hypertensive: Blood pressure >140/90 mm Hg or taking antihypertensive medication.

SOURCE: Murphy, CC, FC Wheeler, MC Weinrich, and DM Shepard. Hypertensive status of diabetics by age, race and sex: Carolina Health Survey, 1982. South Carolina Department of Health and Environmental Control and University of South Carolina, School of Public Health (personal communication).

TABLE 3. *Percent of diabetics and nondiabetics age 18 years and older with hypertension, Michigan, 1980**

Age, Race, and Sex	Diabetics	Nondiabetics	Ratio, Diabetics to Nondiabetics
Age (years)			
18-44	31.9	12.7	2.5
45-64	53.5	41.5	1.3
65+	60.6	48.9	1.2
Race			
White	51.3	25.1	2.0
Black	53.8	29.2	1.8
Sex			
Male	42.2	28.0	1.5
Female	59.0	23.0	2.6
Total	52.1	25.3	2.1

*Hypertension: Blood pressure >140/90 mmHg for subjects ages 18 to 64, >160/90 mmHg for subjects age 65 or older, or taking antihypertensive medication. Diabetes: As reported by the subject.

SOURCE: Michigan Department of Public Health. Diabetes in Michigan: 1980 Survey Results. Division of Chronic Disease Control, 1983.

In southern Wisconsin in 1979-80, a higher prevalence of hypertension was found in diabetic women, particularly at younger ages (Table 4). Prevalence for diabetic females was consistently and markedly higher than for diabetic males and for white nondiabetic males and females.

TABLE 4. *Percent of persons with hypertension among diabetics in southern Wisconsin and among white United States residents, 1971-80**

Current Age (Years)	Wisconsin Diabetics, 1979-80		U.S. White Adults, 1971-75	
	Males (N=2,266)	Females (N=2,838)	Males	Females
30-34	7	20	7.5	2.2
35-44	15	25	14.0	6.6
45-54	20	31	22.6	13.9
55-64	24	34	25.2	27.6
65-74	23	33	30.8	34.9
75+	30	41	-	-

*Hypertension defined as systolic blood pressure ≥ 160 mmHg or diastolic blood pressure ≥ 95 mmHg. Criteria for diabetes was random serum glucose ≥ 200 mg/dl or fasting serum glucose ≥ 140 mg/dl, on two or more occasions.

SOURCE: Klein, BEK, R Klein, and SE Moss. Blood pressure in a population of diabetic persons diagnosed after 30 years of age. Am J Public Health 74:336-39, 1984, and Roberts, J, and M Rowland. Hypertension in adults 25-74 years of age. National Center for Health Statistics, Vital and Health Statistics, Series 11, No. 221, April 1981.

Table 5 displays data on the relationships between diabetes and hypertension in 3,456 residents of Rancho Bernardo, California, ages 50-79 years, surveyed in 1972-74. Diabetics, both known and those discovered during the survey, had higher rates of a medical history of hypertension than persons without diabetes (persons whose fasting plasma glucose (FPG) level was less than 140 mg/dl). Persons with previously known diabetes appeared to have the highest rates of hypertension among the three groups. Prevalence of hypertension as measured during the survey also indicated that diabetics had higher rates of hypertension than nondiabetics (FPG less than 140 mg/dl). Among previously known diabetics with FPG greater than 140 mg/dl, the rates of categorial hypertension were twice those of nondiabetics.

Comparison of 615 employed male diabetics of the Dupont Company with 615 age-matched nondiabetics showed that the prevalence of hypertension was 1.3 to 2.8 times higher in diabetics (Table 6). Among the small number of females studied, hypertension also appeared to be more prevalent among diabetics.

TABLE 5. *Percent of white adults ages 50-79 years with a medical history of hypertension and with measured hypertension, Rancho Bernardo, California, 1972-74*

Sex and Age (Years)	Nondiabetics*	All Diabetics	Previously Known Diabetics*		Previously Unknown Diabetics*
Medical History of Hypertension					
Males					
50-59	21.1	35.4	42.9		29.6
60-69	28.5	36.7	38.1		33.3
70-79	30.7	30.5	27.9		37.5
Total, 50-79	27.7	34.5	35.4		32.8
Females					
50-59	22.3	43.3	52.9		30.8
60-69	29.5	33.9	34.3		33.3
70-79	38.1	52.9	56.0		44.4
Total, 50-79	29.7	41.3	45.4		34.7
Males and females					
50-79	28.8	37.2	39.2		33.6
Measured Hypertension Excluding Persons on Diuretic Therapy					
			FPG <140	FPG ≥140	FPG ≥140
Systolic blood pressure ≥60 mmHg					
Males, 50 to 79	19.0	24.7	24.6	33.3	19.3
Age-adjusted	19.0	25.0	24.4	27.1	21.5
Females, 50 to 79	15.3	22.3	24.4	41.7	14.6
Age-adjusted	15.3	22.8	23.1	39.6	16.7
Male and females					
Age-adjusted	16.9	23.8	23.7	34.1	18.8
Diastolic blood pressure ≥5 mmHg					
Males, 50 to 79	11.5	14.7	10.5	25.0	12.3
Age-adjusted	11.5	14.4	11.1	19.8	9.5
Females, 50 to 79	9.1	11.7	9.8	25.0	9.8
Age-adjusted	9.1	12.1	9.2	22.5	10.7
Males and females					
Age-adjusted	10.2	13.1	10.0	21.3	10.2

*Nondiabetic: No medical history of diabetes and fasting plasma glucose <140 mg/dl. Previously known diabetics: Medical history of diabetes. Previously unknown diabetics: No medical history of diabetes and fasting plasma glucose ≥140 mg/dl.

SOURCE: Barrett-Connor, E, MH Criqui, MR Klauber, and M Holdbrook. Diabetes and hypertension in a community of older adults. Am J Epidemiol 113:276-84, 1981.

TABLE 6. *Prevalence of hypertension among diabetics (DM) and nondiabetics (nonDM) employed in the Dupont Company, Wilmington, Delaware, 1963**

Sex and Age (Years)	Number of Persons Examined		Number Hypertensive		Percent Hypertensive		Ratio, % DM With Hyp to % NonDM With Hyp
	DM	NonDM	DM	NonDM	DM	NonDM	
Males							
Under 45	134	132	25	9	18.7	6.8	2.8
45-54	228	223	82	61	36.0	27.4	1.3
55-64	253	260	117	81	46.2	31.2	1.5
Total	615	615	224	151	36.4	24.6	1.5
Females							
Under 45	12	12	2	0	16.7	0	-
45-54	20	22	7	0	35.0	0	-
55-64	15	13	11	7	73.3	53.8	1.4
Total	47	47	20	7	42.6	14.9	2.9

*Hypertension: Systolic blood pressure 150 mmHg or more, or diastolic blood pressure 94 mmHg or more, on two successive periodic health examinations. Diabetes: As diagnosed by the subject's physician. Nondiabetics: Persons with no medical history of diabetes.

SOURCE: Pell, S, and CA D'Alonzo. Some aspects of hypertension in diabetes mellitus. JAMA 202:104-10, 1967.

The prevalence of hypertension in male and female diabetics seen at the Joslin Clinic in 1964 was compared with prevalence in the Framingham, Massachusetts population in 1964 and in the United States Survey of Hypertension in 1962 (Figure 1). Hypertension in diabetics over 24 years of age was more prevalent at the Joslin Clinic than in the community-based population or the general population. However, the fact that the Joslin Clinic is a major referral center for diabetics must be considered in determining the importance of these differences. In addition, the Joslin Clinic study encompassed juvenile-onset diabetics, whereas the other two surveys probably included primarily persons with adult-onset diabetes. It is not known if hypertension differs in these two types of diabetes.

BLOOD PRESSURE CHARACTERISTICS OF DIABETICS AND NONDIABETICS

Among diabetics in southern Wisconsin in 1979-80 and persons in a sample survey of the United States population in 1971-75, both systolic and diastolic blood pressure increased with age. Diabetic women had consistently higher age-specific systolic blood pressures than the other three groups but, for diastolic blood pressure, no trend was apparent (Table 7). The National Health Interview Surveys in 1976 and 1977 showed that persons who reported a medical history of diabetes also reported a higher prevalence of hypertension than persons with no medical history of diabetes. This was the case in all three age groups studied (Figure 2). Since age and obesity affect the diagnoses of both diabetes and hypertension, it is important in any study of the two diseases to control for these variables. Even after these adjustments, the higher blood pressures among diabetics compared to nondiabetics remained statistically significant in the Rancho Bernardo population (Table 8).

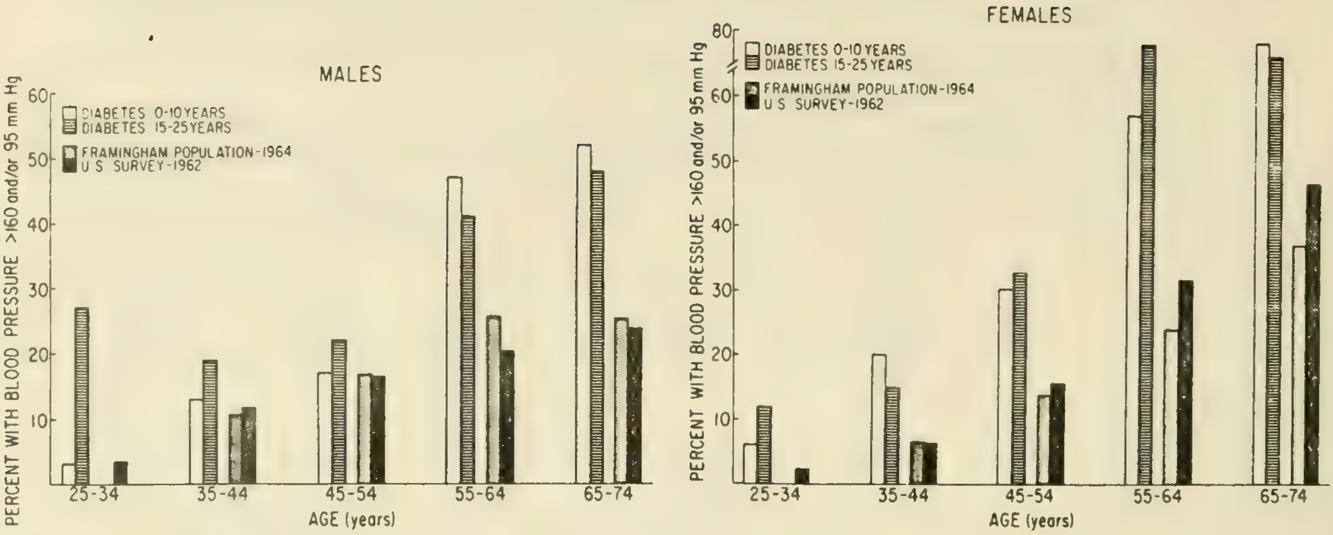

FIGURE 1. *Prevalence of hypertension in male and female diabetics at the Joslin Clinic in 1964, compared to hypertension rates in the Framingham, Massachusetts population in 1964 and the United States Survey of Hypertension in 1962. Diabetes: As diagnosed by subject's physician. Hypertension: Blood pressure greater than 160/95 mmHg.*

SOURCE: Christlieb, AR. Hypertension: The major risk factor in juvenile-onset insulin-dependent diabetics. Diabetes 30 (Suppl 2):90-96, 1981.

TABLE 7. *Mean blood pressure (mmHg) in southern Wisconsin diabetics and in United States white adults*

Age (Years)	Wisconsin Diabetics*, 1979-80				U.S. Whites, 1971-75			
	Males		Females		Males		Females	
	Systolic	Diastolic	Systolic	Diastolic	Systolic	Diastolic	Systolic	Diastolic
30-34	124	77	130	84	125.0	80.0	116.1	74.4
35-44	130	83	134	85	127.2	83.1	120.6	78.4
45-54	135	83	141	85	134.5	86.8	131.0	82.5
55-64	141	82	148	83	140.1	86.1	142.4	84.8
65-74	142	80	149	81	146.8	84.0	152.5	85.3
75+	146	78	152	79	-	-	-	-

*Criteria for diabetes was random serum glucose ≥200 mg/dl or fasting serum glucose ≥140 mg/dl, on two or more occasions.

SOURCE: Klein, BEK, R Klein, and SE Moss. Blood pressure in a population of diabetic persons diagnosed after 30 years of age. Am J Public Health 74:336-39, 1984; and Roberts, J, and M Rowland. Hypertension in adults 25-74 years of age. NCHS Vital and Health Statistics Series 11, No. 221, April 1981.

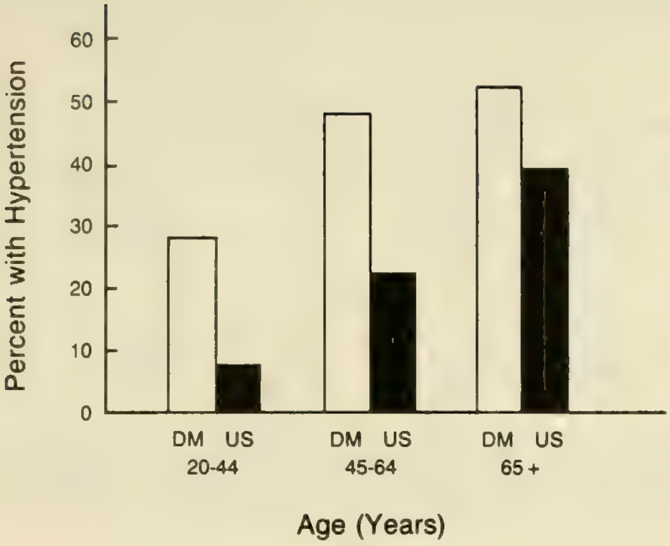

FIGURE 2. *Prevalence of hypertension in diabetics compared to the general United States population, 1976-77. Diabetes: Positive response to the question "Do you have diabetes or sugar diabetes?" Hypertension: Positive response to the question "Do you have hypertension?"*

SOURCE: 1976 and 1977 National Health Interview Surveys, National Center for Health Statistics.

Survey data from England also suggest an association between hypertension and diabetes. Among 24,701 adult members of the Bedford community, blood pressures were compared with blood glucose levels 2 hours after ingesting 50 gm of oral glucose. Compared to normoglycemic persons (less than 120 mg/dl), systolic blood pressures were significantly higher in newly detected diabetics (greater than or equal to 200 mg/dl) and borderline diabetics (120-199 mg/dl) of both sexes, after controlling for age and body mass index (Table 9). An unexpected finding, however, was that diastolic blood pressure was significantly higher only in men with borderline glucose intolerance. In most community surveys of this kind, it is women who have significantly elevated diastolic blood pressures. The Whitehall study, also conducted in England, involved 19,000 British male civil servants over the age of 40. Both systolic and diastolic blood pressures were significantly higher in subjects who had elevated blood glucose levels 2 hours after ingesting 50 gm of oral glucose (Table 10).

In 1979, the World Health Organization reported the results of a multinational study evaluating vascular disease in diabetics (WHO 1979). Figures 3a and 3b display the blood pressure distributions among diabetics in the participating centers of the study. Of note is the finding that women had higher systolic blood pressures than men in most centers.

TABLE 8. *Adjusted mean blood pressure of white adults ages 50 to 79 years, Rancho Bernardo, California, 1972-74*

Sex and Diabetes Status*	Number of Persons Studied**	Mean Age (Years)	Mean Obesity Index	Adjusted Mean Blood Pressure (mmHg)***	
				Systolic	Diastolic
Males					
Nondiabetic	1,149	65.5	3.62	139.6	81.2
Previously unknown diabetic	57	63.7	3.64	140.5	82.8
Known diabetic	93	66.7	3.73	144.3	82.0
Females					
Nondiabetic	1,453	63.7	3.37	135.4	79.8
Previously unknown diabetic	41	62.5	3.49	136.3	79.1
Known diabetic	53	64.6	3.56	142.9	82.4

*Nondiabetics: No medical history of diabetes and fasting plasma glucose <140 mg/dl. Previously unknown diabetes: No medical history of diabetes and fasting plasma glucose ≥140 mg/dl. Known diabetics: Medical history of diabetes.

**Persons taking antihypertensive drugs are not included.

***Adjusted for age, age^2, and obesity by analysis of covariance.

SOURCE: Barrett-Connor, E, MH Criqui, MR Klauber, and M Holdbrook. Diabetes and hypertension in a community of older adults. Am J Epidemiol 113:276-84, 1981.

TABLE 9. *The Bedford, England Survey: Mean values of blood pressure by blood glucose level 2 hours after 50 grams oral glucose, 1962-72*

Age (Years)	Males - Glucose Level			Females - Glucose Level		
	<120 mg/dl	120-199 mg/dl	≥200 mg/dl	<120 mg/dl	120-199 mg/dl	≥200 mg/dl
			Systolic Blood Pressure (mmHg)			
20-29	134.8	139.0	115.0	150.0	140.0	127.5
30-39	130.5	144.9	137.7	131.0	139.0	140.0
40-49	130.4	151.6	136.2	135.3	147.9	144.7
50-59	139.8	153.0	168.9	163.8	166.3	175.2
60-69	146.9	164.2	159.1	159.6	176.1	188.3
70-79	169.7	176.2	175.8	182.5	192.7	187.7
80-89		185.0	161.8		187.5	212.0
			Diastolic Blood Pressure (mmHg)			
20-29	72.8	80.1	75.0	98.0	85.8	88.0
30-39	79.5	89.3	81.0	72.8	87.3	92.1
40-49	79.6	91.2	84.5	78.8	86.6	91.3
50-59	87.5	91.1	95.3	91.9	96.1	96.9
60-69	84.0	89.7	89.3	92.7	93.9	90.6
70-79	95.6	97.3	92.3	93.6	96.0	90.6
80-89		103.8	90.0		96.3	106.0

SOURCE: Jarrett, RJ, H Keen, M McCartney, et al. Glucose tolerance and blood pressure in two population samples: Their relation to diabetes mellitus and hypertension. Int J Epidemiol 7:15-24, 1978.

TABLE 10. *The Whitehall Survey of British male civil servants ages 40-64 years: Mean (±S.D.) blood pressure values by blood glucose levels 2 hours after 50 grams oral glucose, 1968-70*

Blood Glucose Level	Age 40-49	Number	Age 50-59	Number	Age 60+	Number
			Systolic Blood Pressure (mmHg)			
<120 mg/dl	131.4±18.2	7,639	137.5±21.5	8,092	145.8±24.3	3,006
120-199 mg/dl	141.6±18.7	39	146.8±27.6	84	156.1±31.6	71
≥200 mg/dl	142.1±20.0	7	151.5±27.2	29	155.0±20.5	22
Known diabetics	133.2±17.3	46	139.4±20.0	83	144.2±20.8	52
			Diastolic Blood Pressure (mmHg)			
<120 mg/dl	83.0±12.8	7,637	85.1±14.0	8,082	86.4±15.1	3,006
120-199 mg/dl	87.6±13.1	39	90.3±17.2	84	92.3±17.2	71
≥200 mg/dl	92.7± 9.8	7	93.9±16.5	29	92.0±15.3	22
Known diabetics	81.1±12.4	46	82.3±14.1	83	83.9±14.2	52

SOURCE: Jarrett, RJ, H Keen, M McCartney, et al. Glucose tolerance and blood pressure in two population samples: Int J Epidemiol 7:15-24, 1978.

HYPERTENSION AS A RISK FACTOR FOR DIABETES

A study of employed persons indicated that development of hypertension may precede the diagnosis of diabetes. Data from the study suggested that the blood pressures of diabetics began to rise before diabetes was diagnosed, as indicated by the higher proportion of persons with borderline or definite hypertension who later developed diabetes (Table 11). Further, the data indicated that hypertension may increase the relative risk of developing diabetes, as the rate of becoming diabetic was 60 percent higher in borderline and definite hypertensives than in persons with normal blood pressure (Table 12).

BLOOD PRESSURE CONTROL AMONG DIABETICS

Among hypertensive diabetics in South Carolina in 1982, only 20 percent were unaware of their hypertension, compared to 34 percent of nondiabetics (Table 13). Among aware diabetics, although the majority were being treated for their hypertension, in only 36 percent was the hypertension controlled. Overall, among all hypertensive diabetics, hypertension was not controlled in 70 percent, compared to 80 percent of nondiabetics. In Michigan in 1980, a smaller percent (52.1) of diabetics were identified as hypertensive but a similar percent of these (75.8 versus 68 percent in South Carolina) were being treated for hypertension (Table 14). Blood pressure was controlled in 49 percent of Michigan hypertensive diabetics.

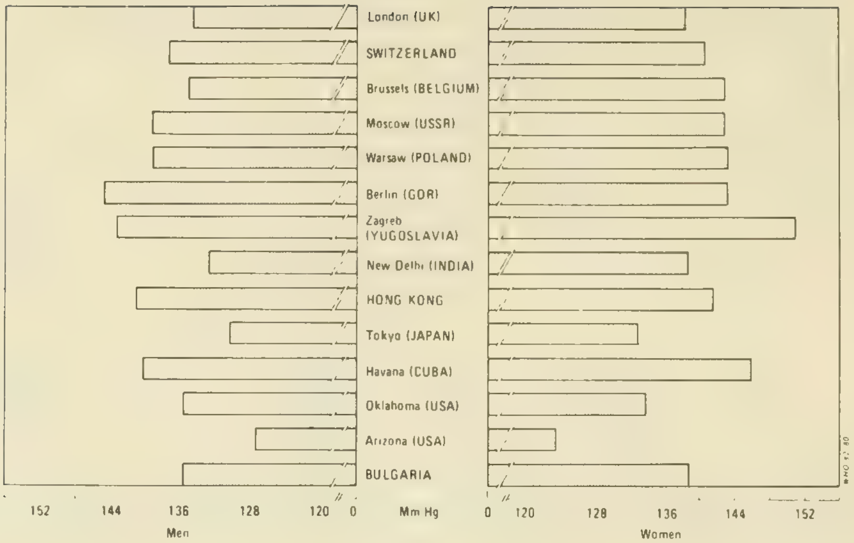

FIGURE 3a. *Mean systolic blood pressure by sex and center*

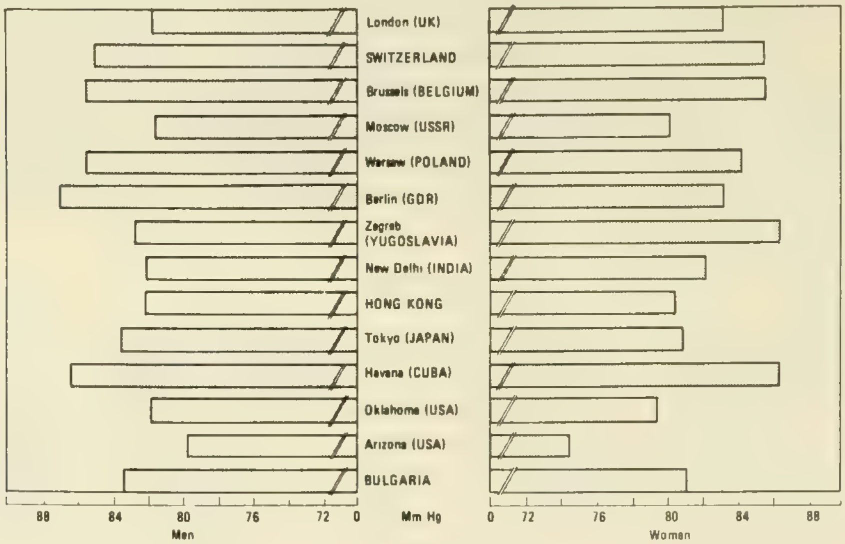

FIGURE 3b. *Mean diastolic blood pressure by sex and center*

SOURCE: World Health Organization. Vascular Disease in Diabetes. Report of the Multinational Study of Vascular Disease in Diabetics. Bern, Switzerland, September 3 to 8, 1979.

TABLE 11. *Distribution of blood pressures of diabetics employed in the Dupont Company 2 years before onset of diabetes versus persons who remained nondiabetic, Wilmington, Delaware, 1963**

Blood Pressure Category at Initial Study	Number		Percent		
	Persons who Became Diabetics	Nondiabetics	Persons who Became Diabetics	Nondiabetics	Ratio, Diabetics to Nondiabetics
Males					
Normotensive	289	340	57.6	69.0	0.8
Borderline	125	88	24.9	17.8	1.4
Hypertensive	88	65	17.5	13.2	1.3
Total	502	493	100.0	100.0	-
Females					
Normotensive	18	28	51.4	80.0	0.6
Borderline	8	2	22.9	5.7	4.0
Hypertensive	9	5	25.7	14.3	1.8
Total	35	35	100.0	100.0	-

*Blood pressure taken within two years before the onset of diabetes. Hypertension: Systolic blood pressure 150 mmHg or more, or diastolic blood pressure 94 mmHg or more, on two successive periodic health examinations. Diabetes: As diagnosed by the subject's physician; Nondiabetics: Persons with no medical history of diabetes at baseline and who did not develop diabetes during the study.

SOURCE: Pell, S, and CA D'Alonzo. Some aspects of hypertension in diabetes mellitus. JAMA 202:104-10, 1967.

TABLE 12. *Relative risk of becoming diabetic among men with borderline or hypertensive blood pressure versus men with normal blood pressure employed by the Dupont Company, Wilmington, Delaware, 1963*

Age at Onset of Diabetes (Years)	Number of Borderline or Hypertensives Becoming Diabetic*	Relative Risk Versus Normotensives
25-34	19	1.21
35-44	46	1.48
45-54	104	1.90
55-64	44	1.63
Total	213	1.63

*Blood pressure taken within two years before the onset of diabetes. Hypertension: Systolic blood pressure 150 mmHg or more, or diastolic blood pressure 94 mmHg or more, on two successive periodic health examinations. Borderline hypertension: Blood pressure between 140-159/90-94 mmHg; Diabetes: As diagnosed by the subject's physician.

SOURCE: Pell, S, and CA D'Alonzo. Some aspects of hypertension in diabetes mellitus. JAMA 202:104-10, 1967.

TABLE 13. *Hypertensive treatment status of diabetics and nondiabetics ages 18 years and older, South Carolina, 1982**

Diabetes Status	Normotensive	Hypertensive				
		Total Hypertensive	Unaware	Aware--Not Treated	Aware-Treated Controlled	Aware-Treated Uncontrolled
Diabetic						
Number	110	178	35	22	52	69
Percent	38.2	61.8	12.2	7.6	18.0	24.0
Nondiabetic						
Number	3,475	1,441	513	254	297	377
Percent	70.7	29.3	10.4	5.2	6.0	7.7
Total						
Number	3,585	1,619	548	276	349	446
Percent	68.9	31.1	10.5	5.8	6.7	8.6

*Normotensive: Blood pressure <140/90 mmHg. Hypertensive: Blood pressure >140/90 mmHg or taking antihypertensive medication. Diabetes: As reported by the subject.

SOURCE: Murphy, CC, FC Wheeler, MC Weinrich, and DM Shepard. Hypertensive status of diabetics by age, race and sex: Carolina Health Survey, 1982. South Carolina Department of Health and Environmental Control and University of South Carolina, School of Public Health (personal communication).

TABLE 14. *Percent distribution of diabetic hypertensives by treatment status, Michigan adults, 1980**

Treatment Status of Diabetics	Age (Years)		
	18-64	65+	Total
Currently treated for hypertension	65.7	91.6	75.8
A. Prescribed medication	57.7	79.8	66.3
Diet or exercise only	8.0	11.8	9.5
B. Hypertension controlled	38.6	65.5	49.1
Hypertension not controlled	27.1	26.1	26.7
Not currently treated for hypertension	34.3	8.4	24.2
Stopped treatment	7.8	1.2	5.2
Never treated	26.5	7.2	19.0

*Diabetes: As reported by the subject. Hypertension: Blood pressure >140/90 mmHg for subjects ages 18-64, >160/90 mmHg for subjects age 65 or older, or taking antihypertensive medication.

SOURCE: Michigan Department of Public Health. Diabetes in Michigan: 1980 Survey Results. Division of Chronic Disease Control, 1983.

Among persons taking blood-pressure-lowering drugs in the Rancho Bernardo population, male diabetics appeared to have lower systolic and diastolic levels compared to nondiabetic males; for females, blood pressure levels for diabetics were equal to or higher than those of nondiabetic females taking blood pressure-lowering drugs (Table 15). Among persons not taking these drugs, the blood pressures were consistently higher among diabetics compared to nondiabetics. The differences did not reach the level of statistical significance, however.

TABLE 15. *Mean blood pressure (± standard deviation) by treatment status of white adults ages 50 to 79 years, Rancho Bernardo, California, 1972-74*

Sex, Blood Pressure, and Age (Years)	Not Taking Blood Pressure Drugs		Taking Blood Pressure Drugs	
	Nondiabetics*	All Diabetics*	Nondiabetics	All Diabetics
Males				
Systolic				
50-59	129.6 ± 18.8	133.3 ± 17.7	144.5 ± 16.2	142.5 ± 24.6
60-69	139.7 ± 19.6	144.7 ± 22.5	153.1 ± 20.9	151.8 ± 20.7
70-79	146.1 ± 22.6	148.9 ± 22.7	165.9 ± 21.9	156.2 ± 26.0
Diastolic				
50-59	80.3 ± 10.3	85.1 ± 10.0	91.4 ± 8.0	85.5 ± 7.7
60-69	81.8 ± 11.2	83.2 ± 12.0	88.5 ± 9.7	84.7 ± 10.0
70-79	81.1 ± 11.5	78.9 ± 11.0	89.2 ± 11.0	85.1 ± 9.6
Females				
Systolic				
50-59	126.4 ± 20.5	132.1 ± 20.9	142.8 ± 18.5	162.5 ± 49.2
60-69	135.0 ± 19.6	141.5 ± 20.7	147.4 ± 20.4	148.7 ± 17.8
70-79	146.5 ± 22.7	150.7 ± 20.5	157.0 ± 22.9	158.5 ± 17.7
Diastolic				
50-59	78.0 ± 10.7	81.3 ± 12.7	87.6 ± 9.2	88.2 ± 14.7
60-69	80.3 ± 10.5	80.8 ± 9.6	86.0 ± 12.1	86.8 ± 7.6
70-79	81.0 ± 11.5	81.1 ± 11.0	86.1 ± 11.6	86.6 ± 12.2

*Nondiabetics: No medical history of diabetes and fasting plasma glucose <140 mg/dl. Diabetics: Medical history of diabetes or fasting plasma glucose >140 mg/dl.

SOURCE: Barrett-Connor, E, MH Criqui, MR Klauber, and M Holdbrook. Diabetes and hypertension in a community of older adults. Am J Epidemiol 113:276-84, 1981.

COMPLICATIONS AMONG HYPERTENSIVE DIABETICS

Development of the complications of diabetes seems to be accelerated by the presence of hypertension. Studies on the Pima Indian population found a twofold increase in retinal exudates in Pimas whose systolic blood pressure was greater than 145 mmHg, compared to those whose systolic blood pressure was less than 125 mmHg (Knowler et al. 1980). In the WHO Multinational Study, small vessel disease of the eye correlated best with the duration of diabetes and systolic blood pressure. For small vessel disease of the kidney, systolic blood pressure was the major associated variable for both sexes, although it was not clear whether elevated systolic blood pressure was a result of diabetic kidney disease or a cause of it (WHO 1979).

Small studies of clinic patients indicate that hypertension accelerates complications. In six diabetic men, hypertension that was untreated resulted in a progressive decline in renal function, as measured by glomerular filtration rate, and subsequent control of blood pressure with antihypertensive medications significantly reduced the rate of decline in glomerular filtration rate (Mogensen 1982). Similarly, in 12 insulin-dependent hypertensive diabetics, reduction of blood pressure resulted in a significant decline in both albuminuria and glomerular filtration rate even though there was no decrease in postprandial blood glucose levels (Parving et al. 1983).

HYPERTENSION AND DURATION AND CONTROL OF DIABETES

The relationship between current age, duration of diabetes, and prevalence of hypertension in diabetics in southern Wisconsin is presented in Table 16. Although the percent hypertensive increased with age, there was no consistent effect of duration of diabetes within each age group. In the Rochester, Minnesota population in 1945-70, the percent of persons developing hypertension after the diagnosis increased with duration of diabetes, and was 19 percent after 5 years, 37 percent after 10 years, 55 percent after 15 years, and 68 percent after 20 years of diabetes; however, part of this increase may be age-related rather than diabetes duration-related (Palumbo 1983).

TABLE 16. *Percent of diabetics with hypertension by duration of diabetes, southern Wisconsin, 1979-80**

Duration of Diabetes (Years)	Age (Years)							
	30-54		55-74		75+		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
0-4	523	23.1	1,231	25.9	421	36.6	2,175	27.3
5-14	358	26.5	1,436	31.3	510	35.1	2,304	31.4
15+	60	20.0	380	29.2	185	39.5	625	31.4

*Hypertension defined as systolic blood pressure ≥160 mmHg or diastolic blood pressure ≥95 mmHg. Criteria for diabetes was random serum glucose ≥200 mg/dl or fasting serum glucose ≥140 mg/dl, on two or more occasions.

SOURCE: Klein, BEK, R Klein, and SE Moss. Blood pressure in a population of diabetic persons diagnosed after 30 years of age. Am J Public Health 74:336-39, 1984.

The relationship of diabetes control to blood pressure levels was also explored in the southern Wisconsin population. For each of three age groups, mean systolic and diastolic blood pressure values did not change within five levels of glucose control measured by random blood glucose levels (Klein and Klein 1984).

CLINICAL IMPLICATIONS

In 1977, essential benign hypertension was present as a diagnosis in 19.8 percent (3.72 million) of all ambulatory care visits for diabetes to office-based physicians (Sayetta and Murphy 1979). Conversely, 1975-76 diabetes was a diagnosis in 8.1 percent of the annual 37 million visits involving hypertension (Cypress 1979).

As noted above, patients with both diabetes and hypertension can benefit significantly by having their blood pressure lowered. There are, however, no controlled clinical trials to indicate the best therapeutic regimens for lowering blood pressure in hypertensive diabetics. In fact, all agents currently used in the management of hypertension in diabetics have associated complications (Table 17).

TABLE 17. *Antihypertensive drug complications in diabetics*

Drug	Possible Complications
Diuretics	
A. Potassium-losing	
Thiazides	Hypercholesterolemia; hyperglycemia in insulin-independent diabetics
Furosemide	
Ethacrynic acid	
B. Potassium-sparing	
Spironolactone	Hyperkalemia with cardiac arrhythmias
Triamterene	
Beta-adrenergic blocking drugs	
Propranolol	Heart failure; obscure symptoms of hypoglycemia; hyperosmolar coma (one report)
Metoprolol	
Sympathetic inhibitors	
Methyldopa	Orthostatic hypotension; impotence
Clonidine	
Reserpine	
Guanethidine	
Vasodilators	
Hydralazine	Aggravation of coronary heart disease
Alpha-adrenergic blocking agents	
Prazosin	Orthostatic hypotension

SOURCE: Christlieb, AR. Diabetes and hypertension. Cardiovasc Rev Rep 1(8): 609-16, 1980. See the Physician's Desk Reference for complete information regarding drug complications.

Although the management of each diabetic with hypertension needs to be individualized, in general the drugs of first choice, after decreasing dietary salt and calories, are thiazide diuretics and beta blockers, in spite of the complications that they can engender. Drugs such as guanethidine and reserpine, which can cause orthostatic hypotension, are probably not good choices, especially in patients who are already prone to developing orthostatic hypotension. Vasodilator drugs can be used, but tachycardia can be induced by this class of drugs. Angiotensin-converting enzyme inhibitors are efficacious in the treatment of patients with high-renin types of hypertension, but this is less likely to be the case in diabetics, especially those whose hypertension is related to diabetic nephropathy, commonly a low-renin form of hypertension. It cannot be overemphasized that treatment of the diabetic patient with hypertension demands a holistic approach, necessitating not only technical skills in controlling the metabolic aspects of diabetes and in safely using antihypertensive agents, but also interpersonal communication skills to optimally manage the patient with these two major diseases.

MORTALITY

In the United States in 1978, hypertensive disease (ICD 400-404) was listed on 30,719 death certificates. Diabetes (ICD 250) was implicated in 10 percent (1,525/15,826) of certificates in which hypertensive disease was selected as the underlying cause of death. Of the remaining 14,893 certificates on which hypertensive disease appeared, diabetes was the underlying cause of death in 1,478 (10 percent). Conversely, hypertensive disease was present on 4.4 percent (1,478/33,841) of certificates in which diabetes was the primary cause of death (NCHS 1983); in 1969 it was present on 10 percent of diabetes death certificates (Pitts 1976).

Hypertension appears to accelerate the atherosclerotic process in diabetics. In Washington County, Maryland, there was a fourfold increase in mortality in hypertensive diabetics compared to normotensive nondiabetics (Table 18). Even among diabetics being treated for hypertension, there appeared to be excess deaths. The relative increase in mortality among hypertensive diabetics compared to hypertensive nondiabetics was 1.51 in the Dupont study population; for persons with borderline hypertension, the relative increase was 2.7 (Table 19).

TABLE 18. *Relative risk of death in diabetics versus nondiabetics, by hypertension status, Washington County, Maryland, 1973*

Blood Pressure and Diabetes Status*	Number of Persons Studied	Deaths		Relative Risk of Death**	96% Confidence Interval
		Number	Percent		
Systolic blood pressure (mmHg)					
Nondiabetics					
<160	606	11	1.82	1.0	-
≥160	136	2	1.47	0.8	0.2-3.6
Diabetics					
<160	249	7	2.81	1.5	0.6-4.0
≥160	122	9	7.38	4.0	1.7-9.6
Treatment for high blood pressure					
Nondiabetics					
Not treated	576	11	1.91	1.0	-
Treated	166	2	1.20	0.6	0.1-2.8
Diabetics					
Not treated	219	8	3.65	1.9	0.8-4.7
Treated	152	8	5.26	2.8	1.1-6.7

*Diabetes: The taking of a glucose-lowering medication within 48 hours before survey.

**Relative risk of death: Ratio of percent of deaths in diabetics compared to percent in nondiabetics with systolic blood pressure <160, or to percent in nontreated nondiabetics.

SOURCE: Dupree, EA, and MB Meyer. Role of risk factors in complications of diabetes mellitus. Am J Epidemiol 112(1):100-12, 1980.

Data from the Hypertension Detection and Followup Program suggest that aggressive management of hypertension in mild hypertensives who have diabetes resulted in a 12 percent lower mortality, although this decrease in mortality is less than that observed with agressive management of hypertension in mild hypertensives without diabetes (17.8 percent lower mortality) (Maxwell 1980).

TABLE 19. *Ten-year death rates of diabetics and nondiabetics by hypertensive status, as of January 1, 1957*

Hypertension* and Diabetes Status	Number of Persons Studied	Deaths		Mortality Ratio, Diabetics/Nondiabetics	P
		Number	Percent		
Normotensive					
Diabetics	144	29	20.5	2.85	<0.01
Nondiabetics	193	14	7.2		
Borderline					
Diabetics	129	33	26.2	2.67	<0.01
Nondiabetics	122	12	9.8		
Hypertensive					
Diabetics	83	30	37.3	1.51	NS
Nondiabetics	42	10	24.7		

*Normotensive: Blood pressure on 2 occasions <140/90 mmHg. Borderline: Blood pressure on 2 occasions between 140/90 and 160/95 mmHg. Hypertensive: Blood pressure on 2 occasions >160/95 mmHg.

SOURCE: Pell, S, and CA D'Alonzo. Factors associated with long-term survival of diabetics. JAMA 214:1833-40, 1970.

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APPENDIX A. *Percent of persons who ever had hypertension, ages 20 years and older, United States, 1976*

	Age (Years)							
	20 and over		20-44		45-64		65+	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons 20 years and over	17.0	46.0	7.8	27.3	22.7	47.7	36.3	52.2
Sex								
Men	14.8	39.2	7.7	21.6	21.1	43.3	28.2	40.7
Women	18.9	51.1	7.9	30.6	24.2	51.8	41.9	59.9
Race								
White	16.3	44.7	7.2	27.4	21.3	45.6	35.4	50.8
Black	23.9	55.5	12.5	28.2	35.8	59.6	46.2	65.6

SOURCE: 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX B. *Number and percent of office visits for essential benign hypertension (401) listed as first, second, or third diagnosis, by other most frequent diagnoses, United States, January 1975-December 1976*

		Hypertension Listed as First Diagnosis		Hypertension Listed as 2nd or 3rd Diagnosis	
Diagnosis	ICDA Code	Number of Visits in Thousands	Percent of Visits	Number of Visits in Thousands	Percent of Visits
All visits	-	46,128	100.0	28,590	100.0
Diabetes mellitus	250	2,054	4.5	4,038	14.1
Obesity	277	4,674	10.1	1,425	5.0
Neuroses	300	1,380	3.0	1,125	3.9
Arteriosclerosis	440	649	1.4	340	1.2
Bronchitis, emphysema, asthma	490-493	575	1.3	948	3.3
Arthritis and rheumatism, except rheumatic fever	710-718	2,038	4.4	2,957	10.3

SOURCE: Cypress, BK. Office visits for diseases of the circulatory system, NAMCS, 1975-76. NCHS Vital and Health Statistics Series 13, No. 40, January 1979.

APPENDIX C. *Age-specific mean systolic blood pressure of diabetics by sex and center, World Health Organization Multinational Study on Diabetes*

		Age (Years)											
		<41			42 to 48			≥49			All		
Center	Sex	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
London (UK)	M	71	126.97	15.73	76	133.58	25.15	107	140.05	18.50	254	134.46	20.70
	F	53	127.06	19.78	87	134.87	22.04	103	147.39	26.58	243	138.47	24.93
Switzerland	M	90	130.40	18.22	98	136.10	16.55	90	145.59	22.72	278	137.33	20.17
	F	87	131.68	18.27	89	142.08	17.97	80	149.05	24.14	256	140.72	21.33
Brussels (Belgium)	M	60	131.07	26.24	71	134.56	20.94	105	137.66	22.69	236	135.05	23.21
	F	58	130.86	23.71	56	143.73	21.54	71	152.73	25.88	185	143.15	25.51
Moscow (USSR)	M	52	132.69	22.83	78	143.78	22.42	96	138.82	25.21	226	139.12	23.99
	F	75	132.07	24.89	108	144.82	30.22	90	150.20	31.56	273	143.09	30.09
Warsaw (Poland)	M	52	130.69	16.23	80	135.00	23.30	109	145.98	23.61	241	139.04	22.98
	F	58	130.40	22.21	84	139.64	21.21	103	153.80	25.70	245	143.40	25.20
Berlin (GDR)	M	83	133.83	18.94	90	142.38	22.75	112	154.91	25.78	285	144.81	24.55
	F	74	128.69	17.97	90	145.50	25.53	111	151.28	21.19	275	143.31	23.73
Zagreb (Yugoslavia)	M	64	135.03	15.46	72	144.79	24.74	84	148.55	21.10	220	143.39	21.62
	F	36	145.81	20.98	69	149.49	20.65	71	155.41	21.31	176	151.13	21.20
New Delhi (India)	M	89	126.44	21.94	102	133.17	22.33	98	137.98	19.33	289	132.73	21.67
	F	68	127.87	17.53	101	138.21	22.21	97	147.53	26.11	266	138.96	23.86
Hong Kong	M	28	136.68	16.22	69	133.90	22.78	101	147.05	23.76	198	141.00	23.26
	F	59	127.29	18.19	60	140.47	22.54	105	150.10	25.18	224	141.51	24.59
Tokyo (Japan)	M	50	124.92	17.88	82	130.52	20.64	103	132.73	18.95	235	130.30	19.49
	F	39	119.77	18.80	57	129.82	22.04	105	139.75	21.17	201	133.06	22.30
Havana (Cuba)	M	79	137.39	22.75	92	135.39	22.32	87	148.32	23.38	258	140.36	23.44
	F	86	136.81	20.42	88	146.84	24.56	83	154.77	24.37	257	146.05	24.23
Oklahoma (US)	M	65	129.54	16.68	94	137.02	18.76	111	137.84	17.08	270	135.56	17.85
	F	86	129.65	16.90	144	131.71	19.77	153	138.34	20.36	383	133.90	19.71
Arizona (US)	M	24	124.25	21.22	29	125.38	16.88	34	131.35	21.66	87	127.40	20.09
	F	31	118.29	17.94	55	121.53	14.98	67	127.69	21.48	153	123.57	18.93
Bulgaria	M	51	125.80	20.97	65	131.83	23.90	106	142.75	23.12	222	135.66	23.87
	F	63	127.44	18.02	80	134.20	19.50	108	148.69	22.14	251	138.74	22.18
TOTAL	M	858	130.60	19.95	1,098	136.03	22.21	1,343	142.56	22.80	3,299	137.28	22.42
	F	873	130.02	20.33	1,168	138.96	23.24	1,347	147.37	24.96	3,388	140.00	24.24

SOURCE: World Health Organization. Vascular Disease in Diabetes. Report of the Multinational Study of Vascular Disease in Diabetics. Bern, Switzerland, September 3 to 8, 1979.

CHAPTER XVIII. CEREBROVASCULAR DISEASE AND DIABETES

Lewis H. Kuller, M.D., Janice S. Dorman, Ph.D.,
and Philip A. Wolf, M.D.

SUMMARY

The annual incidence of stroke was about 175 per 10,000 diabetics 65-84 years of age in Framingham, Massachusetts. In Rochester, Minnesota, the incidence in diabetics of median age 75 years was 101 per 10,000 person-years of study. Numerous studies on incidence, prevalence, and hospitalizations for diabetes and stroke indicate that the occurrence of stroke in diabetics is two to six times greater than in nondiabetics (Table 1). Hypertension is a major risk factor for stroke and is about twice as frequent in diabetics as in persons with normal glucose tolerance. Diabetes is implicated in about 7 percent of deaths due to stroke, and cerebrovascular diseases are present in about 25 percent of deaths due to diabetes. Survival of diabetics after a stroke is poor; only about 20 percent are alive 5 years after a stroke.

Although the methodology of extant studies varies widely, the results consistently identify diabetes as a strong risk factor for cerebrovascular disease. It also appears that in the presence of other conditions, such as hypertension or heart disease, a synergistic effect may occur and the risk of cerebrovascular disease in diabetics may be increased severalfold. Diabetes, or hyperglycemia, is important not only as a precursor of cerebrovascular disease and stroke but also as a metabolic determinant that increases morbidity and mortality following stroke. Hyperglycemia may adversely affect cerebral function and recovery from stroke, as diabetic stroke patients have higher mortality rates and lower survivorship than nondiabetic stroke patients throughout the period after a stroke. Although diabetes appears to predispose to the development of arteriosclerosis, it is likely that elimination of other risk factors for stroke and cardiovascular disease, such as hypertension and cigarette smoking, will reduce the diabetic's risk of stroke.

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TABLE 1. *Summary of studies on stroke in diabetics and nondiabetics*

Reference	Date of Study	Location	Type of Study	Age (Years)	Ratio, Rate in Diabetics vs. Non-Diabetics
a	1976-80	United States	Reported medical history of stroke and diabetes in sample of U.S. residents	45-64 65-74	4.0 2.5
b	1949-74	Framingham, MA	Population-based study of stroke incidence	55-64 65-74 75-84	3.6 3.3 1.8
c	1945-69	Rochester, MN	Population-based study of stroke incidence	Median 75	1.4
d	1965	United States	Prevalence of diabetes in hospitalized stroke patients compared to U.S.	45-69	4.2
e	1972	Seal Beach, CA Birmingham, AL Chicago, IL	Prospective study of stroke in diabetics and nondiabetics	50+ 60-69 50+	1.7-2.6 3.3-5.7 1.9-2.6
f	1979-80	Monroe County, NY	History of diabetes in hospitalized stroke patients vs. the prevalence of diabetes in the general population	Mean 58	3.3
g	1965-74	Honolulu, HI	Incidence of stroke in Japanese American men with blood glucose >122 mg/dl vs. ≤122 mg/dl	45-68	3
h	1965-70	Chicago, IL	Incidence of stroke in probability sample of persons receiving old age assistance	65-74	1.3
i	1960-67	Jerusalem, Israel	History of diabetes in newly diagnosed stroke patients	40-49 50-59 60+	6 3 2
j	1978-81	Tilburg, The Netherlands	History of diabetes in hospitalized stroke vs. nonstroke patients	40-74	2.2

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METHODOLOGIC PROBLEMS IN THE STUDY OF STROKE AND DIABETES

It is often difficult to determine whether or not a stroke has occurred, and in most cases it is even more difficult to ascertain the mechanism of the stroke. No laboratory tests for stroke approach the sensitivity and specificity of the electrocardiogram and cardiac muscle enzyme determinations used for the diagnosis of myocardial infarction. The computerized tomographic (CT) scan, generally available for the past 5 years, represents a major advance in confirmation and diagnosis of stroke. During 1982, 359,000 CT scans of the head were performed in United States hospitals, of which 82,000 (23 percent) were for a principal diagnosis of cerebrovascular disease (Graves 1984). The CT scan is the most efficient test in distinguishing strokes due to hemorrhage from those secondary to infarction. However, definite CT scan changes are often absent immediately following a cerebral infarct and are not seen until 7 to 10 days later. Certain anatomic locations that are frequent sites of brain infarction, notably the thalamus and brain stem, are usually not seen in sufficient detail in a CT scan to confirm the occurrence of ischemic stroke. Another type of ischemic stroke, the lacunar infarct, is often below the resolving power of the scan and goes undetected. These lacunar strokes are a consequence of small vessel disease and may occur more frequently in diabetics. Determination that a stroke has occurred is best made on the basis of a neurologist's clinical evaluation at the time of the acute event. Review of hospital records for the diagnosis of stroke and for determination of stroke subtype is generally unsatisfactory. Since the pathologic processes underlying stroke due to large artery occlusive disease (atherothrombosis) clearly differ from lacunar infarction (lipohyalinosis) and from stroke due to embolism from the heart, it is not unreasonable to assume that precursor factors such as diabetes may be of varying importance in each of the various stroke types. Efforts to distinguish between stroke subtypes should be made in order to address this question.

Studies of diabetes as a precursor of stroke have been hampered by changing diagnostic criteria for diabetes and the fact that glucose tolerance tests in fasting subjects have not been obtained in many instances. Thus, undiagnosed diabetics have not been included in most studies. In addition, while patients being treated with diet, hypoglycemic agents, and even insulin may in truth be diabetic, strict criteria for diabetes have not generally been applied.

Prospective (longitudinal) studies of stroke and diabetes have the advantage that risk factor profiles for participating individuals can be obtained before the development of disease. However, these studies generally require lengthy followup periods, during which time individuals may be lost to followup or may experience changes in risk factors. Death certificates listing both stroke and diabetes have been used to investigate cerebrovascular disease mortality among diabetic individuals. There are, however, inaccuracies in listing causes of death on the certificate, failure to list stroke or diabetes when they were present prior to death, and geographic and temporal variations in death certification practices by physicians. Despite these limitations, mortality data from death certificates can provide an accessible and reasonably accurate method of estimating cause-specific mortality (particularly when information concerning all causes of death listed on the death certificate is utilized). However, studies based on death certificate entries of stroke and diabetes are far less satisfactory and probably far less valid than studies of diabetic patient records.

TYPES OF STROKE IN DIABETIC PATIENTS

In the Nationwide Cerebrovascular Disease Study, diabetes was listed on the hospital record of 9.8 percent (15/152) of strokes involving subarachnoid hemorrhage, 11.6

percent (39/337) involving cerebral hemorrhage, 21.1 percent (98/463) with cerebral thrombosis, and 15.5 percent (45/290) of undetermined stroke type (Kuller et al. 1969). In the Rochester, Minnesota diabetic population in 1945-69, the various types of strokes for 113 diabetics were identified from clinical and postmortem data. Ischemic cerebral infarction accounted for 88 percent, intracerebral and subarachnoid hemorrhage for 8 percent, and indeterminate type for 4 percent (Roehmholdt et al. 1983). In the Jerusalem district of Israel in 1960-67, the proportion of diabetics experiencing ischemic stroke or an undetermined type of stroke was similar (about 20 percent), while the proportion of diabetics with hemorrhagic stroke was slightly lower than for the other two stroke types (about 15 percent). There was little variation in these proportions by age (Lavy et al. 1973).

PREVALENCE AND INCIDENCE OF STROKE AMONG DIABETICS

In the United States in 1976-80, 4.8 percent of diabetics age 45-64 years and 12.7 percent age 65-74 years reported that they had experienced a stroke, compared to 1.2 percent and 5.1 percent of persons with normal glucose tolerance in equivalent age groups (Table 2). In 1977, cerebrovascular disease was involved in about 1 percent of the 18.8 million visits for diabetes to office-based physicians (Sayetta and Murphy 1979). In Pennsylvania in 1973, cerebrovascular disease was listed on 6.1 percent of 378 hospital records of patients with diabetes (Table 3). The frequency of co-occurrence was similar whether diabetes was selected as the primary or the secondary reason for the hospitalization. The proportion increased with age, was similar for males and females, and was higher among white than among nonwhite diabetic patients.

TABLE 2. *Percent of persons who reported a medical history of stroke, by venous plasma glucose values 2 hours after 75 grams glucose, United States, 1976-80**

	Age (Years)		
Glucose Tolerance Status	45-64	65-74	45-74
Medical history of diabetes	4.8	12.7	7.7
Undiagnosed diabetes (≥200 mg/dl)	6.9	4.7	6.1
Impaired glucose tolerance (140-199 mg/dl)	1.2	2.9	1.8
Normal (<140 mg/dl)	1.2	5.1	2.0

*In the 1976 National Health Interview Survey, the percent of diabetic and nondiabetic persons reporting a medical history of stroke was: age 45-64 years, 4.6 percent and 1.3 percent; age 65+ years, 5.5 percent and 4.6 percent.

SOURCE: Harris, MI, National Diabetes Data Group. Data from the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

Among 5,184 stroke-free diabetic and nondiabetic men and women age 30 to 62 years in the general population of Framingham, Massachusetts in 1949, 345 initial cases of stroke occurred during the following 24 years, 168 in men and 177 in women. Atherothrombotic brain infarction (ABI) was the most common type of stroke, accounting for 60 percent of cases. The incidence of this type of stroke was significantly higher for diabetics than for nondiabetics in all age groups (Figure 1).

TABLE 3. *Number and percent of first-admission hospitalizations for diabetes involving cerebrovascular diseases in all hospitals in Pennsylvania, 1973*

Hospitalization Characteristic	Diabetes as Primary Diagnosis		Diabetes as Secondary Diagnosis	
	Number	Percent	Number	Percent
Age (Years)				
0-14	1	1.5	-	0.0
15-44	-	0.0	4	0.9
45-64	12	2.3	75	4.4
65+	40	8.6	246	8.8
Sex				
Male	19	3.9	133	6.7
Female	34	4.2	192	6.4
Race				
White	42	4.8	275	6.9
Nonwhite	11	2.7	50	5.2
Total	53	4.1	325	6.6

SOURCE: Pennsylvania Hospital Discharge Survey, 1973.

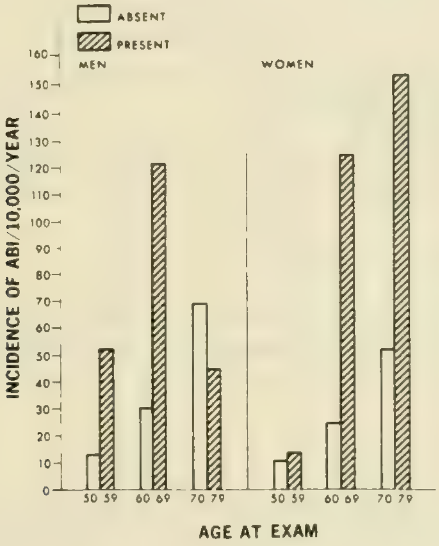

FIGURE 1. *Incidence of atherothrombotic brain infarction in diabetic and nondiabetic men and women, Framingham, Massachusetts, 1949-74*

SOURCE: Wolf, PA, WB Kannel, and TR Dawber. Prospective investigations: The Framingham Study and the epidemiology of stroke. In: Schoenberg, BS, ed. Advances in Neurology, Vol 19. New York: Raven Press, 1978. pp. 107-120.

Among a population of 1,010 primarily noninsulin-dependent diabetics diagnosed between 1945 and 1969 in Rochester, Minnesota, 113 first strokes occurred, representing an incidence of 10.1 per 1,000 person-years of study (Table 4). Both sexes were equally affected. However, when analyzed by the hypertensive status of the diabetic patients, the relative risk was elevated only for diabetics with hypertension, suggesting that the increased risk of stroke was due to hypertension rather than to diabetes.

TABLE 4. *Frequency of first stroke among diabetic patients by hypertension status, Rochester, Minnesota, 1945-1969*

Patients*	Person-Years of Observation	Number of Strokes: Observed (Diabetics)	Number of Strokes: Expected (General Population)	Relative Risk (Observed/ Expected)	P Value	95% Confidence Intervals of Observed/ Expected
All diabetics						
Males	5,430	56	41.0	1.4	-	-
Females	5,748	57	41.2	1.4	-	-
Both sexes	11,178	113	82.2	1.4	-	-
Hypertensive						
Males	1,136	22	10.7	2.1	<0.001	1.3-3.1
Females	2,576	36	23.5	1.5	<0.05	1.1-2.1
Both sexes	3,712	58	34.2	1.7	<0.001	1.3-2.2
Nonhypertensive						
Males	4,294	34	30.3	1.1	NS	0.8-1.6
Females	3,172	21	17.7	1.2	NS	0.7-1.8
Both sexes	7,466	55	48.0	1.1	NS	0.9-1.5

*113 strokes occurred in 1,010 persons who had not experienced a stroke before the diagnosis of diabetes; median age at occurrence of stroke = 75 years; median duration of diabetes = 6 years; median duration of hypertension = 8 years.

SOURCE: Roehmholdt, ME, PJ Palumbo, JP Whisnant, and LR Elveback. Transient ischemic attack and stroke in a community-based diabetic cohort. Mayo Clin Proc 58:56-58, 1983.

DIABETES AS A RISK FACTOR FOR STROKE

It has been clearly demonstrated that diabetics are at increased risk of developing cerebrovascular disease. In the United States in 1976-80, a medical history of stroke was 2.5 to 4 times more common in diabetics than in persons with normal or impaired glucose tolerance (Table 2).

The medical records of hospitalized stroke patients age 45-69 years were examined in the National Cerebrovascular Morbidity Study in 1965, and 16.7 percent of hospital records of stroke patients also listed diabetes (Table 5) compared to a diabetes prevalence in this age group of only about 4 percent. There was little variation in the percent by geographic location, with the exception of a low frequency of diabetes for stroke patients in South Carolina and a high frequency in Buffalo, New York. In a community-wide surveillance system in Monroe County, New York, 129 persons of mean age 58 years were registered who had a history of hypertension and experienced a stroke during 1979-80. A history of diabetes was present in 27 percent of these stroke cases (Barker et al. 1983), which was 3.3 times the diabetes prevalence of 8 percent in a general population of hypertensives without stroke age 50-70 years enrolled in the Hypertension Detection and Followup Program in the mid-1970s (HDFP 1979).

In three United States populations studied for stroke risk factors in 1972, individuals with a medical history of diabetes had approximately a two- to six-fold increased risk of stroke compared to nondiabetic individuals. This risk from diabetes was higher than that conferred by a number of other risk factors for stroke (Table 6).

TABLE 5. *Presence of diabetes on hospital charts of stroke patients age 45-69, 1965*

Area	Number of Stroke Cases	Number With Diabetes	Percent With Diabetes
Miami	531	91	17.1
Denver	293	36	12.3
Kansas	130	15	11.5
Seattle	365	44	12.1
Buffalo	532	143	26.9
North Carolina	214	36	16.8
Georgia	93	15	16.1
South Carolina	162	8	4.9
Total	2,320	388	16.7

SOURCE: Kuller, L, H Anderson, D Peterson, et al. Nationwide cerebrovascular disease morbidity study. Stroke 1:86-99, 1970.

TABLE 6. *The relative risk of subsequent stroke among white males and females reporting certain conditions on medical history compared with persons who did not report these conditions*

	Seal Beach, CA		Birmingham, AL 60-69 Years		Chicago, IL	
Medical History	Males	Females	Males	Females	Males	Females
Diabetes	1.7	2.6	3.3	5.7	2.6	1.9
Hypertension	2.2	2.0	7.1	5.1	-	-
Dizziness	2.2	1.4	1.8	2.3	-	-
Heart attack	2.0	1.7	4.4	3.4	-	-
Diplopia	-	-	0.9	7.3	-	-
Memory loss	1.3	1.2	-	4.2	-	-
High cholesterol	1.5	1.6	-	-	-	-
No regular exercise	1.8	1.3	-	-	-	-
Frequent headaches	0.8	0.7	1.5	2.4	-	-
Fainting	2.3	2.2	1.7	0.7	-	-
Smoking	0.5	1.0	1.0	1.0	-	-
Alcohol	1.0	0.5	1.7	-	-	-

SOURCE: Stallones, R, M Dyken, HCH Fang, et al. Epidemiology for stroke facilities planning. Stroke 3:360-71, 1972.

The incidence of first stroke among diabetics in the community-based population of Rochester, Minnesota in 1945-69 was 1.4 times greater than the rate expected from incidence rates in the general Rochester population (Table 4). In the Framingham, Massachusetts population, the incidence of atherothrombotic stroke occurred significantly more frequently among individuals with diabetes than in nondiabetics (Figure 1). The risk of cerebral infarction was increased among diabetics on either insulin or on oral agents/diet (Table 7), with individuals using insulin appearing to be at the highest risk. In addition, the rate of atherothrombotic brain infarction among individuals with blood glucose levels greater than 160 mg/dl was twice the rate among subjects with lower glucose values (Wolf et al. 1983).

TABLE 7. *Incidence of cerebrovascular accident in diabetics, Framingham, Massachusetts, 1949-67*

	Observed Cases	Expected Cases	Ratio
Sex			
Males	8	3.4	2.35
Females	6	2.8	2.14
Treatment			
Insulin	8	3.0	2.67
Orals/diet	6	3.2	1.88

SOURCE: Kannel, WB. Current status of the epidemiology of brain infarction associated with occlusive arterial disease. Stroke 2:295-318, 1971.

During a 6-year study of 7,895 Japanese American men in Honolulu, 133 new stroke cases were identified, 71 percent of which were due to thromboembolism. The incidence of stroke increased with age; however, after adjusting for age, several other variables were also related to the incidence of thromboembolic stroke. These included the quartile of serum glucose 1 hour after a 50-gm glucose load. As presented in Figure 2, the incidence of thromboembolic stroke was higher among individuals with glucose intolerance than among persons in the lowest quartile of serum glucose. The risk associated with an increased serum glucose level remained significant in multivariate analyses and was almost as important as the effect of age (Kagan et al. 1980). Although serum glucose was a strong risk factor for thromboembolic stroke, it did not appear to be so for hemorrhagic stroke since the rates of hemorrhagic stroke did not increase with serum glucose level (Figure 2).

In Jerusalem during 1960-67, approximately 20 percent of newly diagnosed stroke patients had diabetes, which was about four times greater than the prevalence of diabetes in the general population (Lavy et al. 1973). The ratio was highest (six-fold) among patients age 40-49 years, was three times higher among individuals age 50-59 years, and was twice as high as that of the general population for persons age 60 years and older. No significant differences by sex in the prevalence of diabetes or hypertension among stroke patients were found.

A retrospective study of stroke patients who were 40 to 74 years of age at the time of their first stroke and who were treated at a hospital in Tilburg, the Netherlands was conducted in 1978-81 (Herman et al. 1982). These persons were compared to patients of the same age and sex treated at the same hospital with no prior or current history of stroke. Diabetes was present in 15.1 percent of stroke patients but only 7.1 percent of controls. After adjusting for other factors, diabetes was found to be 2.2 times more common in stroke patients.

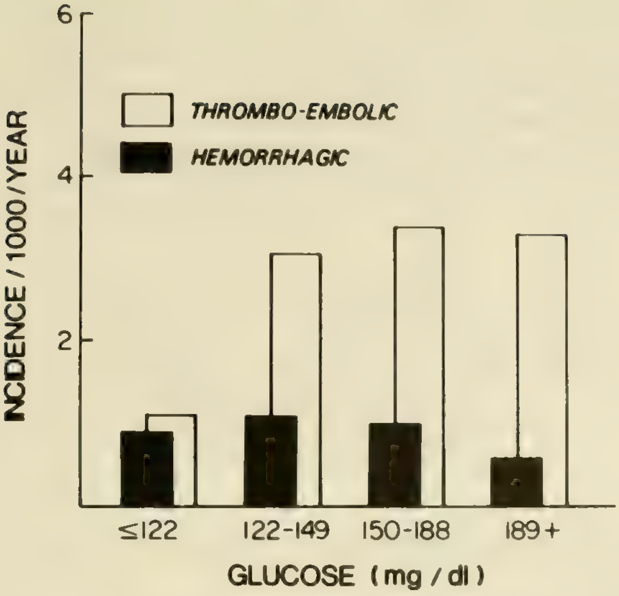

FIGURE 2. *Incidence of stroke by quartile of serum glucose 1 hour after 50-gm oral glucose load*

SOURCE: Kagan, A, JS Popper, and GG Rhoads. Factors related to stroke incidence in Hawaii Japanese men. Stroke 11:14-21, 1980.

Eastern Finland is an area with extremely high mortality rates for cardiovascular disease. In 1972, 4,034 men and 4,334 women age 35 to 59 years were examined. During the next 7 years, 77 men and 65 women had a stroke or transient ischemic attack, of which 34 men and 21 women had a cerebral infarction (Salonen et al. 1982). Among men, a prior history of diabetes was significantly associated with the occurrence of cerebral infarction. A history of diabetes was not significantly related to the risk of all types of cerebral stroke in men, but in women a history of diabetes was significantly associated with both the risk of cerebral infarction and all cerebral strokes (Table 8).

RISK FACTORS FOR STROKE AMONG DIABETICS

Hypertension

There is considerable evidence that hypertension is a major risk factor for cerebral infarction. Consequently, the relationship between diabetes and stroke may be due to increased prevalence of hypertension among diabetic individuals. A medical history of hypertension was 1.5 to 3 times more frequent in diagnosed diabetics than in persons with normal glucose tolerance in the United States in 1976-80 but was equally frequent in diagnosed and undiagnosed diabetics (Table 9). Persons with impaired glucose tolerance were intermediate between diabetics and normals.

The role of hypertension was evaluated in the Rochester, Minnesota population to determine whether the increased incidence of stroke among diabetics could be attributed to their increased prevalence of hypertension. Table 4 describes the frequency of

TABLE 8. *Multiple logistic coefficients for predictors of cerebral infarction and any stroke in 3,750 men and 4,074 women ages 35-59, Finland, 1972-79**

Predictor	Cerebral Infarction		All Cerebral Strokes	
	Men	Women	Men	Women
History of diabetes	0.21^b	0.19^a	0.09	0.19^c
Age at baseline	0.87^c	0.66^a	0.91^b	0.41^b
Diastolic blood pressure	0.47^b	0.15	0.41^c	0.20
Smoking	0.57^c	-0.02	0.52^c	0.02
Serum cholesterol	0.12	-0.12	0.16	0.07
Serum triglycerides	0.08	0.12	0.07	0.07
Body-mass index	0.08	-0.17	0.03	-0.18
History of stroke	0.17^b	0.19^c	0.15^b	0.18^c
Number of events	34	21	77	65

*Significance based on two-sided test, shown as $^a p < 0.05$, $^b p < 0.01$, and $^c p<0.001$.

SOURCE: Salonen, J, P Puska, J Tuomilehto, and K Homan. Relation of blood pressure, serum lipids, and smoking to the risk of cerebral stroke. Stroke 13:327-33, 1982.

TABLE 9. *Percent of diabetics and nondiabetics with medical history of risk factors for cerebrovascular disease, United States, 1976-80*

Reported Condition	Age (Years)				
	20-74	20-44	45-54	55-64	65-74
High blood pressure					
Diagnosed diabetes	56.2	40.0	54.7	62.9	62.9
Undiagnosed diabetes*	50.0	31.2	51.4	50.5	58.9
IGT*	42.4	18.8	36.7	58.7	56.8
Normal*	21.4	14.1	27.0	31.7	40.4
Hardening of the arteries					
Diagnosed diabetes	11.2	0	11.2	10.1	19.9
Undiagnosed diabetes	1.9	0	0	0.9	5.6
IGT	6.7	0	0	13.9	14.4
Normal	1.8	0.2	2.8	2.9	8.6
Smoke 1-10 cigarettes per day					
Diagnosed diabetes	6.0	5.9	5.8	6.9	4.4
Undiagnosed diabetes	8.9	16.4	7.8	9.2	5.4
IGT	6.0	7.5	4.0	5.7	7.1
Normal	8.8	9.6	7.3	7.2	9.6
Smoke 11-20 cigarettes per day					
Diagnosed diabetes	9.9	18.0	9.3	8.7	6.5
Undiagnosed diabetes	11.0	0	27.7	8.8	5.1
IGT	15.2	18.2	10.6	19.5	12.9
Normal	16.0	17.7	17.0	12.6	8.9
Smoke 21+ cigarettes per day					
Diagnosed diabetes	9.3	15.5	14.8	6.9	3.9
Undiagnosed diabetes	11.2	12.9	22.7	5.5	6.3
IGT	8.0	10.6	13.5	0	7.7
Normal	9.4	9.9	12.3	9.0	1.7

*National Diabetes Data Group criteria applied to the results of 2-hour, 75-gram oral glucose tolerance tests. IGT = impaired glucose tolerance.

SOURCE: Harris, MI, National Diabetes Data Group. Data from the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

first stroke during 1945-69 among hypertensive and normotensive diabetics compared to the general hypertensive and normotensive populations. The frequency of stroke was 2.1 times higher in hypertensive diabetics than in hypertensive nondiabetics, but there was no increased frequency of stroke in diabetics without hypertension compared to nondiabetics without hypertension. Thus the increased incidence of stroke in diabetics could be attributed to the presence of hypertension. In addition, diabetic patients with poorly controlled hypertension had an increased frequency of transient ischemic attack or stroke compared to well-controlled diabetics (Table 10).

TABLE 10. *Number and percent of maturity-onset diabetic patients with transient ischemic attack (TIA) or stroke based on clinical characteristics at or following the diagnosis of diabetes, Rochester, Minnesota, 1945-69*

Clinical Characteristics	Number	Percent*
Risk factors and clinical observations at diagnosis of diabetes		
Obesity		
Present	371	16
Absent	506	13
Hypertension (>160/95 mm Hg)		
Present	269	16
Absent	692	12
Clinical coronary heart disease		
Present	185	10
Absent	776	15
Abnormal electrocardiogram		
Present	282	12
Absent	601	16
Other observations following the diagnosis of diabetes		
Hypertension		
Treated	257	19
Untreated	161	20
Hypertension		
Controlled	163	14
Not controlled	194	21
Diabetes control**		
Good or excellent	499	14
Poor	206	22

*67 patients who had the diagnosis of TIA or stroke before the diagnosis of diabetes was established have been excluded; age- and sex-adjusted to the total of 961 cases.

**Good or excellent: 50 percent or more of random blood glucose values less than 150 mg/dl; poor: more than 50 percent greater than 150 mg/dl.

SOURCE: Palumbo, PJ, LR Elveback, and JP Whisnant. Neurologic complications of diabetes mellitus: Transient ischemic attack, stroke, and peripheral neuropathy. In: Schoenberg, BS, ed. Advances in Neurology. Vol. 19. New York: Raven Press, 1978. pp. 593-601.

In Jerusalem in 1960-67, the prevalence of hypertension was twice as frequent among diabetic stroke cases compared to the total population of stroke patients (Lavy et al. 1973).

Autopsy studies indicate that the frequency of cerebral infarction increases with the degree of cardiomyopathy (enlarged heart), an indicator of the presence and severity of hypertension. Among 5,479 autopsies performed at Kings County Hospital Center in Brooklyn, New York, the frequency of cerebral infarction increased with the severity of cardiomegaly for both diabetic and nondiabetic decedents (Aronson 1973). However, diabetics with either normal heart weight or severe cardiac hypertrophy had a higher frequency of cerebral infarction than did their nondiabetic counterparts, indicating that there was a synergistic relationship between hypertension and diabetes. Autopsied subjects are not a representative population, however, and extrapolation of autopsy findings to the general population of decedents must be done with caution.

In the Framingham, Massachusetts population, the impact of diabetes on the occurrence of atherothrombotic brain infarction (ABI) was substantial and was independent of other risk factors such as hypertension. It was estimated that 14.3 percent of ABI in women and 10.1 percent in men could be attributed to diabetes (Kannel and McGee 1979). In contrast to coronary heart disease, the impact of diabetes on the risk of ABI did not diminish with advancing age in either sex. Diabetic women lose their relative immunity to coronary heart disease, with myocardial infarction and sudden death rates equal to those of men. This is not so for ABI, in which the impact of diabetes was only slightly greater in women than in men (relative risk of 3.1 versus 2.6) (Wolf et al. 1983).

Other Risk Factors

In the United States in 1976-80, a medical history of "hardening of the arteries" appeared to be more frequent in diabetics than in other glucose tolerance groups, but heavy cigarette smoking occurred with about equal frequency (Table 9).

In the Rochester, Minnesota, population in 1945-69, the frequency of transient ischemic attack or stroke was significantly higher among noninsulin-dependent diabetics with poor control of diabetes compared to well-controlled patients (Table 10). However, diabetic patients with obesity, clinical coronary heart disease, or an abnormal electrocardiogram did not have a significantly increased frequency of TIA or stroke. The percent of persons developing stroke after the diagnosis of diabetes increased with duration of diabetes and was 7 percent after 5 years, 14 percent after 10 years, 22 percent after 15 years, and 29 percent after 20 years. Part of this increase may be related to age rather than to duration of diabetes.

Mean glycosylated hemoglobin concentration (GHb) an indicator of glycemia over the previous several months, was found to be higher among 40 nondiabetic patients hospitalized for stroke or TIA (GHb=10.2) compared to nonstroke hospital patients (8.3), and was equivalent to values for ambulatory diabetic patients treated with insulin (10.7) or with oral agents/diet (9.5). Half of the stroke/TIA patients had levels greater than 10, indicating that unrecognized hyperglycemia may commonly precede stroke or TIA (Riddle and Hart 1982).

Autopsy data indicate that more severe cerebral atherosclerosis occurs among diabetics compared to nondiabetics, which may contribute to the higher rates of stroke in diabetics. Among 304 autopsies on diabetics and 4,729 on nondiabetics in 1961-65 at the University of Minnesota Hospitals and the Hennepin County (Minnesota) General

Hospital, the degree of cerebral atherosclerosis in blood vessels of the Circle of Willis was about twice as severe among diabetic males and females as among nondiabetics (Flora 1968). For deaths occurring at ages 55 to 65 years, diabetic females had a higher degree of cerebral atherosclerosis than even diabetic males. This investigation provided a more accurate pathological determination of the degree of cerebral atherosclerosis than clinical studies utilizing noninvasive techniques, and it indicated that the association between diabetes and stroke may be due to increased severity of cerebral atherosclerosis among patients with diabetes. However, as previously mentioned, autopsied populations may not be representative of all diabetic or nondiabetic individuals.

MORTALITY

Death Certificate Data

In the United States in 1978, diabetes (ICD 250.9) and cerebrovascular disease were present together on 20,265 death certificates (Table 11). Diabetes was implicated in 7.1 percent of all deaths due to cerebrovascular disease, and cerebrovascular disease was listed on 25.1 percent of death certificates in which diabetes was the underlying cause of death. The same percentages were found in deaths occurring in 1969 (Pitts 1976). The association between diabetes and cerebrovascular disease increased with age regardless of which was selected as the underlying cause of death. In Maryland in 1960-62, diabetes was present on 8.4 percent of death certificates listing cerebrovascular disease for persons age 50-79 years at death (Table 12). Diabetes and stroke were more often listed together for females than for males in three geographic areas of the state, indicating that variations in these rates were probably not a result of local differences in assigning the causes of death. The higher female rate may reflect a higher prevalence of diabetes or an increased risk of vascular complications among females with diabetes versus males.

TABLE 11. *Co-occurrence of diabetes and cerebrovascular disease on death certificates, United States, 1978*

Age (Years)	Number of Diabetes (250.9) Underlying Cause Deaths	Number (and Percent) With Cerebrovascular Disease (430-38)	Number of Cerebrovascular Disease (430-38) Underlying Cause Deaths	Number (and Percent) With Diabetes (250.9)
All	30,993	7,786 (25.1)	175,629	12,479 (7.1)
1-4	11	2 (18.2)	100	0 (-)
5-14	13	4 (30.8)	199	2 (1.0)
15-24	67	5 (7.5)	473	3 (0.6)
25-34	417	35 (8.4)	902	10 (1.1)
35-44	749	71 (9.5)	2,384	68 (2.9)
45-54	1,935	257 (13.3)	6,348	361 (5.7)
55-64	5,094	900 (17.7)	15,322	1,245 (8.1)
65-74	8,972	2,318 (25.8)	36,390	3,493 (9.6)
75-84	9,351	2,869 (30.7)	62,974	4,850 (7.7)
85+	4,382	1,325 (30.2)	50,331	2,446 (4.9)

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

Studies of Diabetic Patients

Among patients at the Joslin Clinic with diabetes onset before age 20 (presumably insulin-dependent diabetes), cerebrovascular disease accounted for 6.8 percent of deaths during 1956-62 (Table 13). However, among diabetics who were 40 years of age or older at onset of diabetes (presumably noninsulin-dependent diabetes), cerebrovascular disease was responsible for 13.9 percent of deaths. This increased from 11.6 percent among those with diabetes for less than 10 years to 16.7 percent for those with diabetes for 20 or more years. The overall rate was about twice that of nondiabetics (Entmacher et al. 1964). A 26-year study of 21,447 diabetic patients at the Joslin Clinic during 1930-56 indicated that mortality from cerebrovascular disease among diabetics was 17 percent greater than expected from rates in the general population (Kessler 1971).

TABLE 12. *Number of death certificates listing cerebrovascular disease and percent also listing diabetes for persons age 50-79 years at death, Maryland, 1960-62*

Race and Sex	Number Listing Cerebro-Vascular Disease*	Percent Listing Diabetes
White male	674	6.3
White female	672	11.0
Nonwhite male	246	3.9
Nonwhite female	241	11.7
Total	1,833	8.4

*Excludes deaths due to cerebral aneurysm.

SOURCE: Kuller, L, and R Seltser. Cerebrovascular disease mortality in Maryland. Am J Epidemiol 86:442-50, 1967.

TABLE 13. *Percent of deaths with cerebrovascular disease (CVD) as the principal cause of death among Joslin Clinic diabetic patients, 1956-62, Boston, Massachusetts*

	Age at Onset of Diabetes (Years)			
	<20	20-39	40-59	60+
Duration of diabetes (years)				
<10	19	3	9	13
10-19	3	5	12	17
20-29	6	8	16	18
30+	12	11	19	-
Total number of deaths	385	778	2,937	1,621
Number of CVD deaths	26	58	388	244
Percent of total	6.8	7.5	13.2	15.1

SOURCE: Entmacher, PS, HF Root, and HH Marks. Longevity of diabetic patients in recent years. Diabetes 13:373-77, 1964.

In a population-based study of all diagnosed diabetics in Rochester, Minnesota from 1945 to 1970, the causes of death in 510 deceased diabetics were examined (Palumbo et al. 1976). Information was obtained from death certificates, autopsy reports, and medical records. Stroke was reported as the underlying cause of death for 5 percent of diabetic males and 7 percent of diabetic females. Since these diabetics were identified from multiple sources in addition to death certificates, these data may be representative of stroke mortality among diagnosed diabetics.

Among 4,121 persons living in Maryland who were age 40 or older when first studied in 1954, 207 had died from stroke by the end of 1966; of stroke deaths in the 40-79 year age group (n=189), 3.2 percent had reported a medical history of diabetes in 1954. This frequency of diabetes was twice as high as among surviving individuals (1.6 percent), although the difference was not statistically significant (Kuller and Tonascia 1971). The results of a multiphasic screening examination in 1954, which included measurement of blood glucose 1 hour after 50 grams of glucose, were compared for 35 persons who died of stroke and 35 survivors. While 14 percent of persons who died of stroke had blood glucose greater than 160 mg/dl in 1954, only 3 percent of survivors had elevated blood glucose; persons who died of stroke also had 7-fold higher incidence of positive urine glucose when examined in 1954.

Among 800,000 persons in the United States age 40-79 years in 1959 who reported no prior history of heart disease, stroke, or cancer, 0.5 percent died of cerebrovascular disease during the next 6 years (Hammond and Garfinkel 1969). Stroke mortality rates among individuals with diabetes but not hypertension were 1.4 to 3.7 times higher than among persons with neither condition, but were lower than for persons with only hypertension (Table 14). The excess was slightly higher for females. Although the number of deaths among individuals with both diabetes and high blood pressure was small, it appeared that there was an even greater relative increase in stroke mortality among individuals with both diabetes and high blood pressure. However, there were no significant differences in the causes of death for diabetic and nondiabetic individuals (Table 15). Heart disease and stroke accounted for the majority of deaths among all patients.

Among 10,538 diabetics whose disease was ascertained through their applications for life insurance in 1951-70, 1,478 died during this period. Cerebrovascular disease was listed on the death certificates of 5.8 percent as the underlying cause of death (Goodkin 1974).

SURVIVAL OF DIABETIC STROKE PATIENTS

To investigate the survival of diabetic and nondiabetic stroke patients, individuals admitted to Umea University Hospital in Sweden at first stroke or TIA during 1972-73 were studied for 5 years (Asplund et al. 1980). Patients included 53 stroke patients with diabetes, 53 nondiabetic stroke cases whose sex, age, and diagnosis of cerebrovascular disease were similar to the diabetics, and 53 randomly selected nondiabetic patients with stroke. Diabetics with stroke had a significantly poorer survival compared to matched nondiabetic stroke patients (p less than .01) or compared to randomly selected nondiabetic stroke patients (p less than .001) (Figure 3). Approximately half the diabetic patients died within 1 year of their first stroke, and only 20 percent were alive after 5 years, compared with 40 percent of the other study patients. No significant differences in causes of death were found (Table 15).

TABLE 14. *Death rates and mortality ratios for stroke by history of diabetes and high blood pressure, United States, 1959-65*

Sex and Age (Years)	Neither Diabetes Nor High Blood Pressure	High Blood Pressure But Not Diabetes	Diabetes But Not High Blood Pressure	Both Diabetes and High Blood Pressure
		Death Rates Per 100,000 Persons		
Men				
40-49	17	68	-	-
50-59	44	227	126	-
60-69	163	507	258	729
70-79	604	1,311	839	2,011
Women				
40-49	12	72	-	-
50-59	28	91	83	-
60-69	86	244	320	440
70-79	393	737	837	779
		Mortality Ratios		
Men				
40-49	1.00	4.00	-	-
50-59	1.00	5.16	2.86	-
60-69	1.00	3.11	1.58	4.47
70-79	1.00	2.17	1.39	3.33
Women				
40-49	1.00	6.00	-	-
50-59	1.00	3.25	2.96	-
60-69	1.00	2.84	3.72	5.12
70-79	1.00	1.88	2.13	1.98

*Based on 2,194 stroke deaths in 358,534 men and 1,905 stroke deaths in 445,875 women.

SOURCE: Hammond, EC, and L Garfinkel. Coronary heart disease, stroke, and aortic aneurysm. Arch Environ Health 19:167-82, 1969.

TABLE 15. *Percent of deaths due to first stroke and to other causes during a 5-year followup*

Cause of Death	Diabetics (n=42)*	Matched Nondiabetics (n=33)	Nonmatched Nondiabetics (n=34)
First stroke	33	42	30
Recurrent stroke	14	21	30
Heart disorders	50	24	42
Pulmonary embolism	7	21	9
Bronchopneumonia	19	21	12
Uremia	2	0	0
Others	2	6	12

*n denotes number of deaths during followup of each group of 53 persons. More than one cause of death was recorded in several patients. There were no significant differences in the causes of death for diabetic and nondiabetic individuals. Heart disease and stroke accounted for the majority of deaths among all patients.

SOURCE: Asplund, K, E Hagg, C Helmers, F Lithner, T Strand, and P Wester. The natural history of stroke in diabetic patients. Acta Med Scand 207:417-24, 1980.

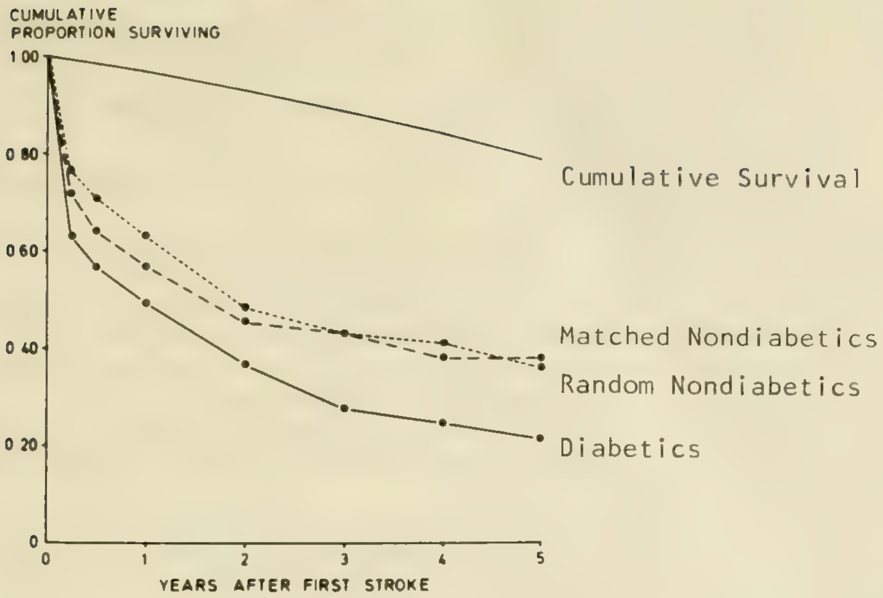

FIGURE 3. *Five-year survival after first stroke in diabetics, matched nondiabetics, and randomly selected nondiabetics, and cumulative survival in the general population matched with diabetics for age and sex*

SOURCE: Asplund K, E Hagg, C Helmers, F Lithner, T Strand, and P Wester. The natural history of stroke in diabetic patients. Acta Med Scand 207:417-24, 1980.

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APPENDIX A. *Number of persons who report ever having had a stroke per 1,000 population, United States, 1976*

	Age (Years)							
	20+		20-44		45-64		65+	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons	13.9	64.8	1.5	6.4	14.1	51.4	54.9	105.9
Men	14.2	69.0	1.3	6.1	14.3	51.5	64.2	118.5
Women	13.7	61.6	1.8	6.6	13.9	51.4	48.4	97.4
White	13.6	65.4	1.3	7.8	12.5	48.5	54.8	108.0
Black	18.3	66.6	3.3	0.0	29.4	69.6	57.7	102.3

SOURCE: Drury, TF. Data of the 1976 National Health Interview Survey, National Center for Health Statistics.

CHAPTER XIX. INFECTIONS IN DIABETICS

Richard A. Kaslow, M.D., M.P.H.

SUMMARY

Most infections appear to be no more common in diabetics than in nondiabetics, although their clinical consequences may be more severe. Kidney and urinary tract infections have most consistently been found to occur at relatively higher rates. Diabetes is also a pre-existing condition in a significant proportion of certain fungal infections and in other unusual clinical entities such as invasive external otitis. Infections account for about 15 percent of hospital admissions of young diabetics, and mortality due to infections is reported to be the cause of about 1 percent of deaths of diabetics.

INTRODUCTION

There is a large body of knowledge about the role of diabetes in producing abnormalities of white blood cell function and in other aspects of the immune response to infection. However, very few studies have related these findings to the actual development of infection in persons in whom these immune defects were found. Certain types of infection do occur with greater frequency or severity in diabetic than in nondiabetic persons, but many published inferences about infectious consequences of diabetes go beyond what available data permit. Further, dramatic changes in medical care, especially the use of antimicrobial agents, render much early information about infection obsolete.

Despite some evidence for excess risk of infection in diabetics, knowledge of the major factors responsible for that risk is fragmentary, and many factors are suspected only on the basis of clinical impression. For most infections, the widely held clinical tenet that ketoacidosis itself predisposes to infection has not been well documented epidemiologically, and the conviction that risk of infection is related to the degree of hyperglycemic control is hard to verify with published data.

Severity and longevity of diabetes have been thought to influence the occurrence of infection, but their influence has not been separated from that of age itself. Exten-

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sive clinical experience has strengthened the belief that both sensory neuropathy and peripheral vascular disease promote the development of infection. Impaired ability to anticipate or recognize injury to tissue and impaired ability to perfuse the traumatized tissue would logically contribute to infectious processes. However, the closely related effects of diabetic control and duration of the disease remain to be sorted out. Still other, often overlooked characteristics of diabetics that alter the likelihood of infection are their frequent hospitalization, instrumentation, and antimicrobial use. Again, informative data are largely missing.

SYNDROMES RESULTING FROM EXTENSION OF SURFACE INFECTION

Clinical Presentation

Diabetics may have a tendency to carry a heavier load of surface pathogens and to experience more mild superficial clinical infections such as furunculosis. The tendency toward infection as a result of penetration by surface inhabitants such as staphylococci, as well as group B and other streptococci, may be largely responsible for several progressive syndromes seen with relatively high frequency in diabetics:

Ulceration and gangrene. Histopathologic findings of inflammation, mainly in the distal portions of the extremities, e.g., toes, are diagnostic, and superimposed necrosis implies gangrene. Physical examination reliably identifies the clinical condition. When any of a variety of bacteria are isolated from the lesions, infection is considered to be contributing to, if not causing, the ulceration or gangrene.

Wound infection. Inflammatory changes in tissue around a traumatic or surgical wound or purulent drainage signifies infection at any body site when accompanied by a positive stain or culture for bacteria or fungi.

Osteomyelitis. The inflammatory component of bone infection can be demonstrated by direct tissue examination, X-ray, or radionuclide scan. In conjunction with a stain or culture that is positive for the usual pathogens, bone inflammation is diagnostic of osteomyelitis. Other approaches can be taken to a presumptive diagnosis. For example, typical findings on a radiograph or scan along with a positive blood culture would be strong evidence. Osteomyelitis in diabetics is usually secondary to soft tissue infection or, in the vertebral column, to urinary tract infection.

Necrotizing fasciitis/cellulitis and gas gangrene. The features that define these syndromes include ulceration, inflammation, or necrosis of the skin with copious fluid drainage; clinical or radiographic demonstration of subcutaneous gas; and isolation of mixtures of aerobic and anaerobic bacteria. Diagnostic procedures are readily available. The greatest difficulty lies in distinguishing colonization from significant infection when there is equivocal growth of organisms and mildly inflamed gangrenous or wound tissue. Moreover, none of these conditions is unique to diabetes; the first two are common enough in the general population to occur coincidentally in a diabetic.

Incidence/Prevalence

Population-based data. No data are available on the occurrence of infected ulcers or gangrenous appendages separate from that summarized in the chapter on peripheral vascular diseases in this volume. Quasi-population-based data have been derived from studies of nosocomial wound infection. In a large collaborative study (NAS 1964), the difference in post-operative wound infection rates between diabetics (10.4 percent) and nondiabetics (7.4 percent) disappeared when overall rates of infection were adjusted for age (diabetics = 7.2 percent). Unadjusted data from a study of eight community hospitals from 1971 to 1973 indicated that 1.7 percent of hospitalized diabetics and 0.6 percent of other patients developed a surgical wound infection with a gram-negative organism (Stamm et al. 1977). No data on osteomyelitis or necrotizing infections were found.

Patient series. Early data include a report (Williams 1942) of 8 cases of boil or carbuncle in 330 diabetics (2.4 percent) as compared with 166 in 26,879 nondiabetics (0.6 percent). Among 521 diabetic patients admitted to one referral center for selected vascular-orthopedic problems, 278 (53 percent) had infectious and noninfectious foot complications; 49 of these (9 percent) had evidence of gas gangrene (Bessman and Wagner 1975). Because various cutaneous and soft tissue infections are aggregated differently in published reports, meaningful overall data are not available from patient series. Inconsistent observations on wound infection in single centers are probably due to differences in patient selection and analytic techniques. One large study of clean wounds (Cruse and Foord 1973) demonstrated infection rates of 10.7 percent in diabetics and 1.8 percent in nondiabetics (rates not adjusted for age). Considering only clean orthopedic surgical wounds, Scandinavian investigators serving an entire community did not detect a higher frequency of infection in diabetics (Lidgren 1973). Although studies of small numbers of patients suggest a higher risk for diabetics (Stone and Bonfiglio 1963), there are no published studies containing useful data on the frequency of osteomyelitis or necrotizing infection in sites other than the foot.

Mortality. Dissemination of surface infections beyond the sites where they originate is accompanied by high mortality. Ketoacidosis and other complicating features may place the diabetic at even higher risk of death, but accurate epidemiologic data are not available.

URINARY TRACT INFECTION

Clinical Presentation

Diabetics appear to be at higher risk of several forms of urinary tract infection. The most common is asymptomatic bacteriuria (defined as greater than 10^5 organisms per ml of aseptically collected urine). Symptoms and signs on physical examination in conjunction with a positive culture constitute clinically significant infection. When gas-forming bacteria produce shadows in a distinctive radiographic picture either around the kidney or the bladder, the clinical entities are called, respectively, emphysematous pyelonephritis or emphysematous cystitis. Papillary or medullary necrosis represents significant destruction of the renal collecting system; it is diagnosed by a combination of clinical signs (flank tenderness, excretion of cellular material) and typical X-ray changes. Any significant collection of pus around the kidney is usually identified by radiographic or scanning techniques as a perinephric abscess and confirmed by diagnostic aspiration, surgical drainage, or response to antimicrobial therapy.

Incidence/Prevalence

Accurate incidence figures are not available for urinary tract infection in diabetics.

Population-based data. In a sample survey of United States residents in 1976-80, a medical history of kidney and urinary tract infections was reported in about equal frequency by diabetics and persons with normal glucose tolerance, although in the age group 20-44 years there appeared to be somewhat higher rates among diabetics (Table 1). However, no confirmatory laboratory evidence was obtained in this survey.

TABLE 1. *Percent of persons reporting a medical history of infections, by diabetes status, United States, 1976-80*

Infections and Diabetes Status*	Age (Years)				
	20-44	45-54	55-64	65-74	45-74
Kidney or urinary tract infection					
Diagnosed diabetic	46.5	31.2	24.1	23.0	25.6
Undiagnosed diabetic	31.7	26.1	44.7	16.2	29.6
IGT	23.2	16.4	15.2	12.2	14.8
Normal glucose tolerance	26.1	22.6	25.9	24.6	24.2
Urinary tract infection					
Diagnosed diabetic	20.2	11.1	7.5	9.6	9.2
Undiagnosed diabetic	16.9	8.1	12.2	6.9	9.2
IGT	6.7	9.2	2.0	4.5	5.4
Normal glucose tolerance	9.8	7.7	6.4	6.3	6.9
Bladder infection					
Diagnosed diabetic	24.8	19.1	12.6	10.9	13.7
Undiagnosed diabetic	28.0	10.0	23.7	5.7	13.6
IGT	19.7	6.9	9.4	6.5	7.6
Normal glucose tolerance	13.2	11.8	14.2	12.6	12.8
Kidney infection					
Diagnosed diabetic	20.8	20.9	11.3	13.3	14.6
Undiagnosed diabetic	8.3	20.7	24.0	9.1	18.0
IGT	8.6	9.0	3.8	6.8	6.6
Normal glucose tolerance	13.2	11.0	10.3	11.7	10.9
Tuberculosis					
Diagnosed diabetic	3.1	3.6	2.5	1.0	2.2
Undiagnosed diabetic	0	0	4.1	2.1	2.2
IGT	0	3.3	0	2.4	1.9
Normal glucose tolerance	0.3	0.9	1.6	1.1	1.2
Chronic bronchitis					
Diagnosed diabetic	11.7	17.8	8.6	8.3	11.0
Undiagnosed diabetic	8.1	3.5	6.1	6.3	5.4
IGT	7.6	2.0	8.1	10.3	6.5
Normal glucose tolerance	5.3	5.5	6.0	10.6	6.8
Hepatitis					
Diagnosed diabetic	3.5	6.2	2.0	3.5	3.7
Undiagnosed diabetic	0	4.6	4.9	1.3	3.6
IGT	0	0	5.7	2.6	2.7
Normal glucose tolerance	2.7	2.1	2.8	1.0	2.1
Yellow jaundice					
Diagnosed diabetic	1.9	6.3	6.5	6.5	6.6
Undiagnosed diabetic	4.7	4.6	1.8	3.1	3.1
IGT	0	1.7	8.3	4.0	4.6
Normal glucose tolerance	2.7	4.1	3.7	4.6	4.1

*National Diabetes Data Group criteria. IGT = impaired glucose tolerance.

SOURCE: Harris, MI, National Diabetes Data Group. Unpublished data from the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

Patient series. Numerous collections of data on diabetic patients with significant bacteriuria have been published. Surveys of nonhospitalized patients more often than not indicate higher colonization rates in diabetics than in nondiabetics (Table 2). Most

TABLE 2. *Prevalence of bacteriuria in nonhospitalized diabetic patients, and examination of factors other than diabetes that might account for differences between diabetics and nondiabetics*

		Study Data				Y = Factor Was Examined but Did Not Appear to Account for Difference Between Cases and Controls					
				Percent with Bacteriuria							
Reference	Asymptomatic Bacteriuria	Sex	Number of Diabetics^{1}	Diabetics	Controls	Source of Controls	Age	Sex	Pregnancy	Instrumentation, Pelvic Surgery	Organism
a	+, F and M	F	54	18	6	Y		Y			
		M	37	5	4						
b	+	F	91	19.7	18.7	Y	Y	Y			Y
		M	59	3.3	1.7						
c		F	81	19	4	Y				Y^{2}	Y
		M	67	7	3						
d		F	177	14	-		±^{3}		±^{3}	±^{3}	
		M	342	2	-		±^{3}			±^{3}	
e		F	128	19	8		Y	Y	Y	±^{3}	
		M	141	1	2						
f	+	F	195^{4}	2	-						
		F	183	2	-						
		F	253^{5}	7	-						
g		M/F	212	14.6	-						
h	+	F	149	11	M/F, 3	Y		Y			Y
		M	97	11							
i	+	F	100	9	2.8	Y	Y	Y	Y		
j		F	152	15.8	5	Y	Y	Y	±^{3}	Y	
		M	154	2	1						
k		F	1,325	13.5							
		M	733	2.4							
l		F	111	27^{6}	11.4	Y	Y	Y			
		M	87	8^{6}	29	Y	Y	Y			
m	+	F	47	10.6	8.3	Y	Y	Y			
		M	53	3.7	1.9						

TABLE 2. (Continued)

		Study Data				Y = Factor Was Examined but Did Not Appear to Account for Difference Between Cases and Controls					
				Percent with Bacteriuria							
Reference	Asymptomatic Bacteriuria	Sex	Number of Diabetics[1]	Diabetics	Controls	Source of Controls	Age	Sex	Pregnancy	Instrumentation, Pelvic Surgery	Organism
n	+	M/F	680	17	F 3-5 M 0.5			Y	Y		
o		F M	91 34	12 6	2 4	-[7]	Y				

[1] Proportion of Type I or Type II patients variable

[2] Catheterization noted among men

[3] Factor examined but partial or no direct comparisons

[4] Girls at summer camp

[5] Pregnant women

[6] Blacks only

[7] Subjects drawn from occupational health clinic

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have found that 10-20 percent of diabetic women compared to 2-8 percent of nondiabetic women had asymptomatic bacteriuria, i.e., diabetic women show a three- to fivefold excess risk. Prevalence rates in diabetic men ranged from 2-11 percent and rarely showed more than twofold, if any, difference from rates in nondiabetic men. However, these studies generally have not eliminated selection bias and certain other alternative explanations for the differences observed other than the presence of diabetes.

A carefully conducted cohort study of catheterized inpatients with or without diabetes demonstrated two- to threefold increased odds of urinary tract colonization among the diabetics (Platt 1984).

Emphysematous pyelonephritis or cystitis, papillary/medullary necrosis, and perinephric abscess are uncommon enough that there are no true incidence or prevalence estimates. Rather, these conditions have been observed in clinical settings in which the proportion of cases associated with diabetes seems greater than would be expected even for highly selected hospitalized patients (Table 3). Diabetes appears to play a significant role, although an explanation for its role is lacking.

TABLE 3. *Frequency of diabetes in patients with complicated urinary tract infection*

Reference	Complication	Diabetics/ Total Persons (Number)	Percent Diabetic	Comments
a	Emphysematous pyelonephritis	22/31	72	Cases selected from literature review
b		54/61	89	-
c	Emphysematous cystitis	15/19	79	Average duration 14.2 years; most had "glycosuria" and gas-forming bacteria
d		58/118	49	-
e	Perinephric abscess	19/52	37	-
f	Papillary/medullary necrosis	143/250	57	Literature review; most with diabetes < 15 years' duration
g		95/195	50	Autopsy series, 1,762 diabetics; 97 (5.5%) had renal papillary necrosis
h		5/66	8	Clinical autopsy series

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Mortality

In Osaka, Japan in 1960-74, 0.6 to 1.1 percent of all deaths with diabetes mentioned as a contributory condition had "infection of kidney" listed as the underlying cause of death (Sasaki et al 1978). In Pennsylvania in 1968-69, the comparable figure was 0.7 percent (Tokuhata et al. 1975). Among Joslin Clinic diabetic patients, acute kidney infection was the cause of 0.9 percent (8/912) of deaths in 1966-68, similar to the percent observed during 1922-65 (Joslin 1971).

Risk Factors

Occurrence of urinary tract infection in diabetics generally mirrors its occurrence in the general population with regard to age, sex, and the roles of pregnancy, obstruction, and instrumentation. However, data are inadequate to establish whether the effects of these factors are exaggerated in diabetics. There is even less systematic information on how the risk varies with type, duration, or control of disease, with sexual activity, or with the presence of microvascular disease.

INVASIVE EXTERNAL OTITIS

Clinical Presentation

Invasive or malignant otitis externa is a spreading inflammation of the outer ear canal that often extends into the adjacent structures of the skull and central nervous system. It appears to be due uniquely to Pseudomonas aeruginosa infection.

Incidence/Prevalence

Approximately 90 percent of cases collected in the 15 years since this entity was first described have occurred in diabetics. Population-based data on this condition have not been assembled. A recent review of 151 cases suggested that the condition may be more frequent than previously suspected (Doroghazi et al. 1981), but the frequency even among defined patient cohorts has yet to be determined.

Mortality

Death among patients without extension of infection to the central nervous system is probably no higher than 15 percent. When cranial nerves are involved, the figure may rise to 50 percent or higher in the most extensive cases.

Risk Factors

The mean age of diabetics with this infection is about 67 years, with average duration of diabetes about 16 years. The data do not support an obvious relationship to the degree of diabetic control. The reason for the exclusive role of P. aeruginosa is unknown, but perhaps that organism's propensity to produce a vasculitis is enhanced in tissue already compromised by vascular insufficiency. The relationship between P. aeruginosa and other risk factors has not been explored.

FUNGAL INFECTIONS: ZYGOMYCOSIS

Clinical Presentation

Distinctive clinical manifestations (e.g., sinusitis, necrosis of nasal cartilage, cranial nerve involvement) of rhinocerebral zygomycosis, or bronchopulmonary inflammation with positive stain or culture of affected tissues, are diagnostic of the conditions caused by fungi in the genera Mucor, Rhizopus, and Absidia.

Incidence/Prevalence

Population-based data are not available. A recent comprehensive review of 179 cases of this disease found that 126 (70 percent) had occurred in diabetics (McNulty 1982). Cases have been rather uncommon and only selectively recorded.

Mortality/Survival/Case Fatality

Overall case fatality has been 40 percent, although it has been as low as 15 percent in some patient studies (Pillsbury and Fischer 1977).

Risk Factors

In clinical and experimental investigations of zygomycotic infections, particularly, ketoacidosis appears to be the major determinant of occurrence and/or outcome.

FUNGAL INFECTIONS: CANDIDIASIS

Clinical Presentation

The mucocutaneous form of the infection in the oropharyngeal and vulvovaginal areas is diagnosed when clinical signs of inflammation are seen in conjunction with a positive stain or culture of skin scrapings. When care is taken to identify C. glabrata (formerly Torulopsis glabrata) in the urine in significant numbers, it probably has much the same significance as other Candida species do. Colonization is relatively common although disease is probably not, and the pathogenicity of this organism must be low.

Incidence/Prevalence

No population-based data on Candida have been presented, despite the relatively common clinical experience with these infections. At least 20 percent of patients in two studies whose urine cultures contained C. glabrata were diabetic (Ahearn et al. 1966, Guze and Haley 1958). In one small study and review of clinically significant infections, 2/11 (18 percent) and 9/11 (82 percent) had diabetes (Kaufman and Tan 1974, Marks et al. 1970).

Mortality

These infections are not generally life-threatening since the organisms seldom become blood-borne. In the unusual clinically important infection, fatality due to C. glabrata is quite high, but reliable epidemiologic data have not been published.

Risk Factors

Glycosuria. Clinically, mucocutaneous and urinary tract candidiasis are more often seen in patients who are hyperglycemic and excreting glucose into the urine (Kaufman and Tan 1974).

Antimicrobial therapy. Frequent use of antimicrobial agents is known to predispose patients to colonization with Candida, but there is no evidence of their greater importance in diabetics than in others.

Obstructive uropathy and instrumentation. Predisposing mechanical factors are the same as for other urinary tract infections.

TUBERCULOSIS

Clinical Presentation

Infection with Mycobacterium tuberculosis is often silent. In practice, the presence of infection is usually defined by a positive response to a skin test with purified protein derivative from the organism. Documented conversion of the test from negative to positive signifies occurrence of infection during the interval between tests. When the chest X-ray shows typical changes in conjunction with clinical signs and/or a positive skin test, a presumptive diagnosis of tuberculosis can be made. Definitive diagnosis requires identification of the organism by means of appropriate stain or culture of involved fluid or tissues (sputum, pleura, cerebrospinal fluid, urine, etc.). All of these procedures should be readily available through virtually every medical facility in the United States.

Incidence/Prevalence

There are numerous studies of the co-occurrence of diabetes and tuberculosis, but careful case definitions, population sampling, and analytic approaches have seldom been employed. Because tuberculosis was a major cause of morbidity until fairly recently, the significance of its relationship to diabetes may have been overstated. Although the relationship may well be real, the dramatic overall decline in tuberculosis has left us with inadequate information about the nature and magnitude of the risk in diabetics.

Population-based data. In a sample survey of United States adults in 1976-80, reported rates of a medical history of tuberculosis were low and did not differ between diabetics and persons with normal glucose tolerance (Table 1). Rates of chronic bronchitis were higher and indicated an excess frequency of bronchitis among diabetics. However, no confirmatory clinical findings were obtained.

Patient series. Two studies, while not based on a complete or systematic population sample, did encompass a large proportion of the adult population in defined cohorts and included large numbers of diabetics and nondiabetics. These data are now more than 30 years old, but were probably at least as good as other published data in estimating the "excess" risk of tuberculosis due to diabetes (Figures 1 and 2). Not surprisingly, the actual rates for the Philadelphia and London study populations differed, but for middle-aged men in both studies the prevalence of tuberculosis was two- to threefold higher in diabetics. These investigators and certainly others whose work is often cited (Root 1934) found even higher relative risks in other more disadvantaged segments of the population. In other studies of patients with active or inactive disease (Golli et al. 1974, Edsall et al. 1970, Adetuyibi and Akisanya 1979, Delecour et al. 1979, and Deshmukh et al. 1962), the rates of tuberculosis among diabetics ranged between 0 and 12 percent (usually 3-5 percent), with little attempt to take into account either typical selection factors operating in clinical settings or background rates in the study locale. One relatively recent estimate of the incidence of tuberculosis among adult diabetics in New Zealand (Proust 1977), presumably based on annual development of new active pulmonary disease, was 0.1 percent. Reliable data on the true incidence of infection as measured by annual rates of skin test conversion have not been reported.

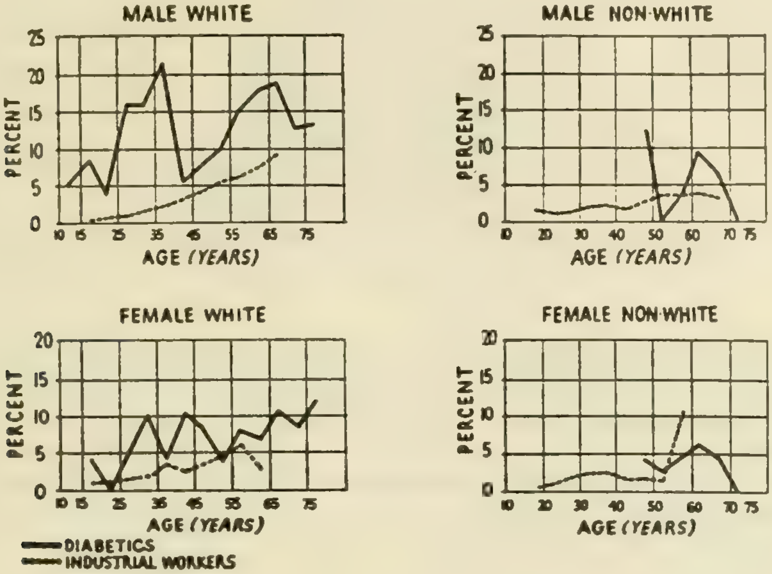

FIGURE 1. *Prevalence of tuberculosis by age, race, and sex--comparison between diabetics and industrial workers, Philadelphia*

SOURCE: Boucot, KR, ES Dillon, DA Cooper, P Meier, and R Richardson. Tuberculosis among diabetics: The Philadelphia survey. Am Rev Tuberc 65, Part II, Suppl. 1:1-50, 1952.

Mortality

Population-based data. Cursory analysis of multiple-cause mortality data for the entire United States for 1978 did not reveal an obvious excess of tuberculosis among diabetics (Kaslow 1984). On death certificates with diabetes named as the underlying cause, tuberculosis was mentioned as a contributing condition in 0.3 percent of deaths, whereas on death certificates with some other condition named as underlying cause, tuberculosis appeared as contributing in 0.4 percent of deaths (Kaslow 1984).

Patient series. Among Joslin Clinic diabetic patients, none of 912 deaths in 1966-68 were due to tuberculosis, continuing the steady decline from 4.1 percent in 1922-36 (Joslin 1971). In a study of autopsies on 1,216 diabetics in Lodz, Poland from 1970 to 1974, 26 (2.1 percent) were considered to have died of tuberculosis (Mroszczyk et al. 1982).

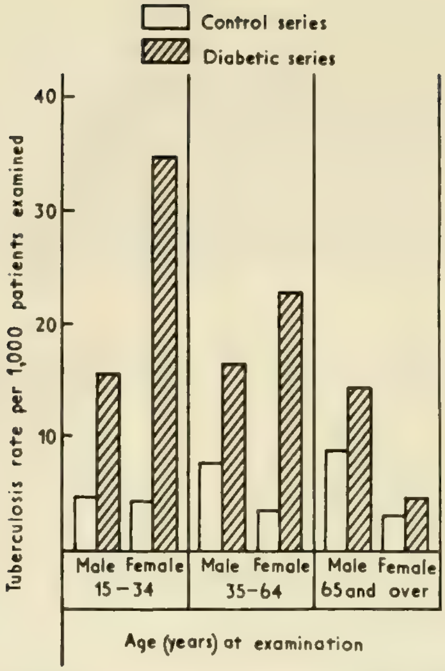

FIGURE 2. *Prevalence of tuberculosis among diabetic patients at University College Hospital compared with a control group at Central Middlesex Hospital, England*

SOURCE: Warwick, MT. Pulmonary tuberculosis and diabetes mellitus. Q J Med 26:31-42, 1957.

Risk Factors

Both diabetes and tuberculosis are age-related, but whether the relationship between the two conditions is modified by age has not been established. Data on sex, race, type and duration of disease, and hyperglycemic control as special factors for tuberculosis in diabetics have not been examined.

LOWER RESPIRATORY TRACT INFECTIONS

Clinical Presentation

A variety of diagnostic approaches are used to define pneumonia. Combinations of physical symptoms and signs (fever, pleuritic chest pain, productive cough) may be unmistakable. More often a chest X-ray, sputum stain or culture, serology, or a procedure such as bronchoscopy or lung biopsy is necessary to make the diagnosis, and difficult cases may exhaust all of these procedures without an unequivocal diagnosis.

Incidence/Prevalence

Little effort has been devoted to studying respiratory infections (other than tuberculosis) as consequences of diabetes. Still, the impression has been left in many authoritative sources that bacterial and viral pneumonias, particularly pneumococcal, staphylococcal and influenza, are more frequent or more severe in diabetics.

Population-based data. In 1976, diabetics had lower rates of influenza than nondiabetics during a period when about one-fourth of the United States population reported an episode of influenza (Table 4).

TABLE 4. *Percent of diabetics (DM) and nondiabetics (nonDM) reporting certain acute conditions, United States, 1976*

	Age (Years)					
	17-44		45-64		65+	
Condition	DM	nonDM	DM	nonDM	DM	nonDM
Infections/parasitic	10.1	9.4	10.0	7.7	11.9	9.8
Respiratory	46.4	54.7	47.9	54.3	34.3	49.8
Upper respiratory	29.7	24.9	18.2	24.0	17.8	26.8
Influenza	14.5	27.8	26.9	27.7	14.8	20.1
Other respiratory	2.3	2.1	2.8	2.6	1.7	2.9

SOURCE: Drury, T. Unpublished data from the 1976 Health Interview Survey, National Center for Health Statistics.

Patient series. Published data are qualitatively and quantitatively inadequate to assess the impact of lower respiratory tract infections in diabetic patients. Among 640 diabetics hospitalized in a 9-month period, 14 cases (2.2 percent) of lower respiratory tract infection were found, but no details or comparison with other types of hospitalized patients were provided (Whitehouse 1973). In another report, 8 of 52 insulin-dependent diabetics developed postoperative nosocomial respiratory tract infection, but no comparison with nondiabetic surgery patients was offered (Garibaldi et al. 1981). In a direct comparison of diabetics and nondiabetics admitted to community hospitals, a slightly higher rate of nosocomial gram-negative pneumonia was observed for the diabetics (0.5 versus 0.3 per 100 patients) (Stamm et al. 1977); however, no details were given.

Mortality

Population-based but indirect observations on causes of death in Osaka, Japan (Sasaki 1984) and comparisons with similar data from the United States in 1978 (Kaslow 1984) can be summarized as follows. Persons had pneumonia or bronchitis recorded as the underlying cause of death about twice as often when diabetes was listed as a contributing condition as when diabetes was absent. However, these comparisons were not age-standardized. Pneumonia was recorded as the underlying cause in diabetics almost twice as often in Osaka (4.0-5.5 percent) as in United States statistics from about 10 years earlier (2.5 percent). Concern over excess risk from respiratory infection derives more from clinical experience with mortality during influenza epidemics and with apparently high (5/120, 4.2 percent, and 6/21, 28 percent) mortality rates in diabetics who have bacteremic pneumococcal pneumonia (Austrian and Gold 1964, Mufson et al. 1974). One report (Khurana et al. 1973) documents case fatality of 40 percent for pneumonia due to Staphylococcus aureus and Klebsiella pneumoniae. Among Joslin Clinic diabetic patients, pneumonia and respiratory tract infection were the cause of 3.5 percent (32/912) of deaths in 1966-68 (Joslin 1971).

Risk Factors

There are well-studied episodes of ketoacidosis in which pneumonia was considered to be a precipitating factor; in two such studies the proportion was 16 percent and 25 percent (Whitehouse 1973, Biegelman and Warner 1973). Sound epidemiologic data demonstrating higher than expected frequencies of influenza or pyogenic pneumonia do not exist. Epidemiologic evidence that metabolic decompensation in diabetics may predispose to pneumonia is even less compelling.

BACTEREMIA

Clinical Presentation

Isolation from blood cultures of a known pathogen and, in certain settings, of an organism usually dismissed as a skin colonist denotes bacteremia. With clinical signs (e.g., fever, chills, hypotension), the diagnosis of clinically significant bacteremia or septicemia is presumed. Extreme signs and symptoms (e.g., profound hypotension, loss of urine output) distinguish septic shock from less severe septicemia. The definition has varied somewhat from one study to another depending on the number of and interval between blood cultures accepted as diagnostic. The vast majority of cases occur secondary to localized infections such as those previously described, so the pattern of occurrence of bacteremia closely reflects that seen with the antecedent infections themselves.

Incidence/Prevalence

There are no firm epidemiologic data on the overall probability of bacteremia among diabetics. There are some indications from diverse clinical studies of patients with bacteremia that unexpectedly high proportions (upwards of 10 percent) of cases occur in diabetics. Data on bacteremia in hospitalized patients is more compelling. In a study of 142 diabetics and age-matched controls (Fourrier et al. 1975), septicemia acquired before or during hospitalization was more common in diabetics (8/71, 11 percent) than in nondiabetics (1/71, 1.4 percent). A large community hospital study of nosocomial gram-negative bacteremia without a known primary site of infection demonstrated a rate of 0.3 per 100 diabetics and 0.1 per 100 nondiabetics (Stamm et al. 1977). Among a group of diabetics and a comparison group undergoing surgery in 1963-64, 7 cases (7.1 percent) of postoperative gram-negative septic shock were found in the diabetics compared with 17 in 4,207 (0.4 percent) other surgical patients (Ariyan and Halasz 1967). The 18-fold difference between the two groups may have been accentuated by differences in the types of surgical procedures.

Mortality

It is not clear how much higher mortality from bacteremia is in diabetics than in other patients. Both the fatality rates for diabetics and the relative rates for diabetics compared with nondiabetics vary among studies, most likely because selection of patients with bacteremia differs from one study to another. In four studies of diabetics and nondiabetics, proportions dying were as follows: 100 percent and 100 percent (Ariyan and Halasz 1967), 39 percent and 20 percent (Lewis and Fekety 1969), 69 percent and 38 percent (Cluff et al. 1968), and 23 percent and 16 percent (Aubertin et al. 1982). A recent clinical review also noted a higher fatality rate in diabetics compared to nondiabetics (Cooper and Platt 1982).

OTHER MEASURES OF IMPACT

Hospitalization and Ketoacidosis

An impact of infection in diabetes was examined in 1979-82 in population-based studies in Rhode Island, where infections were identified as one of the major precipitants of all hospitalizations for insulin-dependent diabetics (Table 5). During the first year of the study, infection was identified as the precipitant of 43 percent of single and 30 percent of multiple admissions for diabetic acidosis. This finding is consistent with an earlier study in 1924-76, in which 29 of 71 patients (41 percent) in Rochester, Minnesota with previously diagnosed diabetes had an infection as the precipitating event in an episode of ketoacidosis (Johnson et al. 1980).

Ambulatory Medical Care

In 1977, 268,000 visits for diabetes to physicians in ambulatory care practices were reported to involve cellulitis, skin abscess, psoriasis, chronic skin ulcers, or other skin disorders (Table 6). In 1975-76, 0.8 percent (760,000) of visits to physicians for acute upper respiratory infections except influenza involved diabetes (Cypress 1979).

TABLE 5. *Percent distribution of primary precipitants for 746 hospitalizations among known IDDM cases aged <30 years, Rhode Island, 1979-82*

Primary Precipitants	Single Admissions (N=351)	Multiple Admissions (N=395)
Poor diabetic control	39%	29%
Infection	17	14
Pregnancy	8	15
Emergency (surgery/trauma)	9	3
Elective Surgery	6	4
Diabetic complications	5	6
Hypoglycemia	6	5
Psychological	3	5
Other	7	19

SOURCE: Falch, GA, HA Fishbein, and SE Ellis. The epidemiology of diabetic acidosis: A population-based study. Am J Epidemiol 117:551-58, 1983.

TABLE 6. *Prevalence of skin conditions associated with a diagnosis of diabetes* in ambulatory medical care practices, United States, 1977*

Skin Condition	ICDA-8 Code	Thousands of Visits with Specified Skin Condition
Other cellulitis and abscess	682	95.4
Psoriasis and similar disorders	696	19.0
Chronic ulcer of skin	707	153.3

*Total office visits reporting diabetes = 18.8 million.

SOURCE: Sayetta, RB, and RS Murphy. Diabetes Care 2:105-19, 1979 (data from the National Ambulatory Medical Care Survey, National Center for Health Statistics).

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APPENDIX A. *Percent of persons who report having been told by a physician that they had "sugar" in their urine, by diagnostic status, United States, 1976-80*

Diagnostic Class	Age (Years) 45-64	 65-74	 45-74
Diagnosed diabetes	71	71	71
Undiagnosed diabetes			
With former diagnosis of pre/pot/bord Dm*	58	65	61
Without pre/pot/bord Dm	4	3	3
Impaired glucose tolerance			
With former diagnosis of pre/pot/bord Dm	11	0	8
Without pre/pot/bord Dm	6	5	6
Normal glucose tolerance			
With former diagnosis of pre/pot/bord Dm	28	31	28
Without pre/pot/bord Dm	2	1	2

*Prediabetes, potential diabetes, borderline diabetes

SOURCE: Harris, MI, National Diabetes Data Group, from unpublished data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

APPENDIX B. *Number and percent distribution of physician visits by all persons for certain acute infections, United States, 1980*

Condition	Thousands of Visits	Percent
All chronic conditions	447,705	51.2
All acute conditions	386,090	44.2
Influenza, all forms	45,564	5.2
Common cold	30,485	3.5
Viral infection, unspecified	11,185	1.3
Other upper respiratory conditions	23,330	2.7
Other respiratory conditions	21,058	2.4

SOURCE: Physician Visits, 1980. National Center for Health Statistics, Vital and Health Statistics, Series 10, No. 144, June 1983.

CHAPTER XX. MATERNAL DIABETES IN PREGNANCY

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SUMMARY

Approximately 4 to 15 per 1,000 pregnancies occur in diabetic women, the majority of which are probably in insulin-dependent diabetics. Estimates of the prevalence of gestational diabetes range from 25 to 50 per 1,000 pregnancies. Advanced maternal age appears to be the most reliable correlate of the occurrence of abnormal glucose tolerance in pregnancy. Gestational diabetes together with history of perinatal mortality, birth of a heavy baby, obesity, age, and family history of diabetes are risk factors for subsequent development of diabetes. Parity does not seem to be a risk factor. Maternal mortality in diabetic pregnancies appears to be no different from the low rate in pregnancies of nondiabetic women.

INTRODUCTION

The highly destructive effects of diabetes on pregnancy that were witnessed in the pre-insulin era have now been virtually eliminated. Before the introduction of insulin, infertility was common, maternal death was a major threat, and perinatal survival was less than 40 percent. Maternal diabetic mortality rates declined dramatically following the introduction of insulin, to the point where such deaths are now extremely rare and appear to be no more frequent than in the nondiabetic population. In addition, the incidence of fetal and perinatal deaths has fallen gradually over the past half-century. The incidence reported by most tertiary care centers is now between 4 and 8 percent (Karlsson and Kjellmer 1972, Tyson and Hock 1976, Gabbe et al. 1977), and, given appropriate management of the pregnancy, a diabetic woman can now be virtually assured of a successful outcome. Nevertheless, the risks of morbidity and mortality to the fetus still remain higher than those in the general prenatal population, and it is generally agreed that management of pregnancy complicated by overt diabetes should

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be conducted in centers familiar with the potential problems of a pregnant diabetic woman (Gyves et al. 1977, Tyson and Hock 1976). In addition, women with gestational diabetes have emerged as a special high-risk population, but criteria for diagnosis of this condition are subject to differences internationally.

METHODOLOGIC PROBLEMS IN STUDYING DIABETES IN PREGNANCY

Diabetes in pregnancy can be classified broadly into two groups, those women with diabetes known to exist prior to the pregnancy and those with gestational diabetes, which is a transient abnormality of glucose tolerance during pregnancy. The distinction has considerable importance. The incidence of gestational diabetes is substantially greater than that of pregnancies among known diabetics. Consequently, incidence rates for diabetes in pregnancy can vary greatly, depending on the proportion of gestational diabetics included in the study. In addition, studies of diabetic pregnancy are often confounded by incomplete case ascertainment. Diabetes is recorded with variable degrees of completeness on vital records. In the State of Washington, birth and fetal death certificates identified three-fourths of pregnancies complicated by known hyperglycemia as recorded on the mother's hospital chart. Preexisting diabetes was more completely reported than gestational diabetes (82 percent versus 69 percent) (Persing and Connell 1984). Washington State has a place on certificates to record maternal diabetes. In South Carolina, however, which does not have such a checkbox on certificates, fewer than 40 percent of pregnancies in which diabetes or hyperglycemia were on the mother's hospital chart were identified through birth and fetal death certificates (Wheeler 1982). Consequently, vital records must be considered suspect sources of accurate data on the incidence of diabetes in pregnancy. In contrast, maternal hospital discharge records in South Carolina identified 90 percent of live births and fetal deaths in which maternal hyperglycemia or overt diabetes was recorded on the vital record. When vital records and hospital records were used together, they provided a reasonable mechanism for identifying pregnancies known to be complicated by maternal conditions (Wheeler 1982). However, the extent to which these three sources underascertained pregnant diabetic women is not known.

Assessment of diabetic pregnancies is also complicated by major numerical variations resulting from a diversity of diagnostic criteria and, when identical criteria have been employed, by differences in the decision rules for their application or in the laboratory methods employed. Moreover, factors of selection occur in virtually all existing prevalence studies through inadequacies in defining the target populations, e.g., when the baseline population of pregnant women has been sufficiently documented to provide a well-defined denominator, the numerator (diabetic women) has been poorly defined, or vice versa. In sum, the quality of data sources and information provided in the literature suggest caution in accepting the accuracy of estimates of the prevalence of diabetes in pregnancy.

CLASSIFICATION OF DIABETIC PREGNANCIES

The White classification of diabetes, based on factors that affect the prognosis for outcome of the diabetic pregnancy, has been a major contributor to facilitating interstudy comparisons. The White classification grades diabetes alphabetically, based on maternal age, disease duration, and the presence or absence of vascular complications. There have been deletions and additions in the years since its first introduction. Given the general improvement in fetal salvage and the growing complexity of the White classification, it is not surprising that simplifications have appeared. Indeed, the distinctions among the original White classes B, C, and D have largely disappeared (White 1971). The most recent revision, in which gestational diabetes is a separate category, is shown in Table 1.

TABLE 1. *White classification (revised) of maternal diabetes*

Gestational diabetes	Abnormal GTT; euglycemia maintained by diet alone, or diet alone insufficient and insulin required
Class A	Diet alone, any duration or onset age
Class B	Onset age 20 yr or older and duration less than 10 yr
Class C	Onset age 10-19 yr or duration 10-19 yr
Class D	Onset age under 10 yr, duration over 20 yr, background retinopathy or hypertension (not preeclampsia)
Class R	Proliferative retinopathy or vitreous hemorrhage
Class F	Nephropathy with over 500 mg/day proteinuria
Class RF	Criteria for both classes R and F coexist
Class H	Arteriosclerotic heart disease clinically evident
Class T	Prior renal transplantation

All classes below A are overt diabetics and require insulin therapy. Classes R, F, RF, H, and T have no onset duration criteria but usually occur in long-term diabetes. The development of a complication moves the patient to the lower class.

SOURCE: Hare, JW, and P White. Gestational diabetes and the White classification. Diabetes Care 3:394-5, 1980.

Other classifications have been recommended. A British group has suggested the following: 1) diabetes diagnosed during the pregnancy; 2) diabetes diagnosed before the pregnancy, with mild or no complications; and 3) diabetes diagnosed before the pregnancy with serious complications (Essex et al. 1973). This appealing classification requires further definition of the terms "mild" and "serious" before it can be properly evaluated. A treatment-oriented classification entitled "Prognostically Bad Signs in Pregnancy" (PBSP) consists of the following four categories: 1) pyrexial pyelitis, 2) ketoacidosis, 3) preeclampsia, and 4) neglectors. Each component of this PBSP was found to be associated with increased perinatal mortality (J. Pedersen 1965).

PREVALENCE OF KNOWN DIABETES AMONG PREGNANT WOMEN

Table 2 suggests that the prevalence of known recorded diabetes in pregnancy is between 4 and 15 per 1,000 pregnancies, depending on the data source and age group studied. However, the rates in Table 2 reflect a composite of physicians' diagnostic standards and lack the uniformity of case ascertainment and standardization that would give full credence to their use as representing accurate prevalence rates. Maternal hospital discharge records appear to be the most valid source of ascertainment of maternal diabetes. Using this data source, in the United States in 1982, diabetes in the mother as a complication of pregnancy and childbirth was recorded in 40,000 deliveries, for a rate of 10.1 per 1,000 deliveries in that year (Table 2). Direct reporting of maternal hospital discharge information to the maternal-child health program in the Illinois State Department of Health showed that the maternal diabetes rate was lower than the U.S. rate and that it was recognized in only 4 per 1,000 pregnancies in 1975. In North Carolina and Washington State, using maternal hospital records, the rate was also lower (5.1 per 1,000).

TABLE 2. *Studies on the prevalence of diabetes, hyperglycemia, and glycosuria in pregnancy*

Reference	Location	Date of Study	Data Source For Maternal Conditions	Prevalence Per 1,000 Pregnancies
Population-Based Studies				
a	Cleveland, OH	1959-63	Retrospective review of all hospital records in the Cleveland area; 447/160,514 pregnancies indicated diabetes	2.8
b	Maine	1975	Birth certificates	4
b	Michigan	1975-76	Birth certificates	6
b	Nebraska	1976	Birth certificates	4
b	Illinois	1975-77	Birth certificates	4
b	Illinois	1975	Maternal hospital records	4
c	Harrisburg, PA	1974-78	12,298 live and dead deliveries occurring with gestation 16+ weeks in 5 greater Harrisburg hospitals serving 99.8% of the area patients in urban, suburban, and rural communities	
			Personal interview with the women at 1 month postpartum determined the presence of diabetes in 188 women prior to pregnancy; mean age >30 years	15.3
			Presence of glycosuria (1+ to 4+) on maternal hospital medical charts of 320 women	26.0
d	North Carolina	1978	Birth certificates	1.2
			Fetal death certificates	33.1
			Maternal obstetric hospital record	5.1
			All three sources	5.1 (white)
			All three sources	6.9 (nonwhite)
e	United States	1978	Application of U.S. fertility rates to the known prevalence of women with diabetes	
			Age 20-29 (13,300 theoretical pregnancies)	6.2
			Age 30-34 (4,670 theoretical pregnancies)	9.8
f	Washington State	1979-80	Maternal hospital records	
			IDDM (N = 303)	2.3
			NIDDM (N = 54)	0.4
			GDM (N = 317)	2.4
			TOTAL	5.1
g	United States	1982	National Hospital Discharge Survey, NCHS; of 3,945,000 deliveries in hospitals, 40,000 were recorded as involving diabetes in the mother (ICD 648.0)	10.1

(Continued)

TABLE 2. (Continued)

Reference	Location	Date of Study	Data Source For Maternal Conditions	Prevalence Per 1,000 Pregnancies
Patient Populations				
h	Collaborative NIH Perinatal Project	1959-65	Women enrolled in a prospective study in 15 university-affiliated medical centers in the U.S.; 125/18,915 white women were diabetic by medical history; 129/19,966 black women were diabetic	
			Total with medical history of diabetes	6.6 (white) 6.5 (black)
			Medical history of diabetes of 5+ years' duration	2.7 (white) 1.1 (black)
			Abnormal glucose tolerance test	7.5 (white) 7.9 (black)
i	Los Angeles	1964-65	652 women in second and third trimesters selected from obstetric prenatal clinics of LA/UCLA Medical Center. None had a medical history of diabetes; fasting glucose >100 mg/dl was considered criterion for diabetes (N = 23)	7 (age <20) 23 (age 20-30) 71 (age >30)

TABLE REFERENCES

a. Miller, M, and ME Black. Concurrent problems: Pregnancy. In: Denowski, T, ed. Diabetes Mellitus: Diagnosis and Treatment. American Diabetes Association, 1964.
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e. Harris, MI, National Diabetes Data Group, based on data of the 1978 U.S. National Health Interview Survey, NCHS, and Final Natality Statistics, 1978, Monthly Vital Statistics Report, Vol. 29, No. 1, Supplement April 28, 1980.
f. Connell, F. Washington State diabetic pregnancies. CDC Diabetes Control Program Update, March 1983.
g. 1982 U.S. Hospital Discharge Survey, National Center for Health Statistics.
h. Niswander, KR, and M Gordon, eds. The Women and Their Pregnancies. Philadelphia: W.B. Saunders Co., 1972.
i. Mestman, JH. Screening in mothers with mild glucose intolerance. Diabetes Care 3:447-52, 1980.

An independent estimate of overt diabetes in pregnancy can be made from the number of women of childbearing age who have known diabetes as reported in household interviews in 1978. If these diabetic women ages 20-29 years underwent pregnancy at the same rate as all women of the same age in the United States (112 pregnancies per 1,000 women) (NCHS 1980), an estimated 6.2 per 1,000 pregnancies would have occurred in women with known diabetes diagnosed before the pregnancy (Table 2). For diabetic women ages 30-34 years, the rate would be 9.8 per 1,000.

It is often unclear to what extent diabetic pregnancy rates reflect overt diabetes in the mother or transient gestational diabetes. In Washington State, an attempt was made to determine which type of diabetes existed by examining the mother's hospital record. While the total rate (5.1 per 1,000) was similar to the rates found in other states, only half appeared to have overt diabetes, and of these only a small proportion (15 percent) had noninsulin-dependent diabetes mellitus (NIDDM) (Table 2). Gestational diabetes constituted the other half of diabetic pregnancies identified through the mother's medical record.

The prevalence rate in the Cleveland study in 1959-63 is quite representative of the rates at that time and probably represents the prevalence of known diabetes. In the Pennsylvania study, performed 15 years later following a time of extensive national screening for diabetes, prevalence was 5 times greater, which may reflect increased awareness and greater recognition of earlier stages of diabetes and probably includes some unknown number of gestational diabetics. No uniform diagnostic standards were presented in either retrospective evaluation, and the White subclassifications were not provided, so confirmation of this explanation of the difference is not possible. However, the mean age of the Pennsylvania women may have been higher than in Cleveland, which may account for a substantial part of the difference.

The NIH Collaborative Perinatal Project, based on multicenter study enrollees, provides prevalence data that are open to question because of biases in selection of participants and deliberate oversampling of diabetic women. In the Los Angeles study in Table 2, the endpoint was fasting glucose greater than 100 mg/dl, which is not now considered adequate to classify a woman as an overt diabetic. Vital records from several States show that maternal diabetes was recorded on birth records in 1.2-6 cases per 1,000 births, but, as discussed above, vital records underestimate the prevalence of diabetes in pregnancy. The rate of maternal diabetes among fetal death certificates was much higher (33.1 per 1,000), reflecting the importance of diabetes in causing fetal death.

GESTATIONAL DIABETES MELLITUS

Criteria for Diagnosis

The diagnosis of gestational diabetes mellitus (GDM) is generally based on a 100-gram, 3-hour oral glucose tolerance test; women with two or more glucose levels exceeding those in Table 3 are considered to have gestational diabetes. Modifications of these

TABLE 3. *Diagnostic criteria for gestational diabetes using the fasting glucose concentration and glucose values after 100-gram glucose challenge**

	Venous Whole Blood (mg/dl)	Plasma/Serum (mg/dl)
Fasting	90	105
One-hour	165	190
Two-hour	145	165
Three-hour	125	145

*Diagnosis of gestational diabetes requires two or more values ≥ the glucose concentrations in the table.

SOURCE: O'Sullivan, JB, and CM Mahan. Criteria for the oral glucose tolerance test in pregnancy. Diabetes 13:278-85, 1964.

criteria have been suggested. The American Diabetes Association (ADA) Workshop on Gestational Diabetes recommended subclassification of patients with gestational diabetes based on whether or not the fasting plasma glucose value exceeds 105 mg/dl as being prognostic of pregnancy outcome (ADA 1980). The World Health Organization suggested that the criteria for diabetes in nonpregnant adults may also be used for pregnant patients (WHO 1980). The National Diabetes Data Group recommended that confirmation of the clinical diagnosis of GDM requires retesting after parturition (NDDG 1979).

Prevalence of GDM

Estimates of the prevalence of GDM in the general population range between 25 and 50 per 1,000 pregnancies (Table 4). This is several times the prevalence of known diabetes per 1,000 pregnancies (Table 2). The prevalence of gestational diabetes in the Boston and Cleveland studies, which employed the diagnostic criteria in Table 3, was similar (25 and 32 per 1,000). Los Angeles data based on criteria that excluded women who had fasting values greater than 100 mg/dl indicated a 4.5-fold higher rate (113 per 1,000), even though both sets of data were based on venous, whole blood values from 3-hour, 100-gram oral glucose tolerance tests. The high prevalence rate in the Los Angeles study suggests that factors were involved that would select for a higher proportion of patients with elevated glucose levels. These factors are shown in Table 4, but reanalysis of the Los Angeles data indicated that past family and obstetric history and obesity are all correlated with age of the patient. The rates of GDM increase with age in both analyses of the Los Angeles data, and this factor probably explains the higher GDM prevalence.

Screening for GDM

Screening for GDM is important because identification and treatment of gestational diabetics has reduced perinatal mortality in infants of gravid women over 25 years of age (O'Sullivan et al. 1973). Information on screening for gestational diabetes (defined as meeting the criteria in Table 3) employing a 50-gram oral glucose challenge is provided in Table 5. Using the criterion of 130 mg/dl blood glucose level 1 hour after 50 grams of glucose, 79 percent of gestational diabetics were identified and 87 percent of women without GDM were accurately classified. Using the criterion of plasma glucose greater than or equal to 143 mg/dl, a second study found 83 percent of GDMs could be detected by the 1-hour screen, and 47 percent of women without GDM were accurately classified (Table 5).

The ADA Workshop on Gestational Diabetes recommended that all women considering pregnancy be evaluated for diabetes risk factors (previous gestational diabetes, history of large babies, family history of diabetes, diabetic symptoms, and glycosuria) (ADA 1980). If a woman is found to have these risk factors, a fasting plasma glucose value greater than or equal to 105 mg/dl or a random glucose value greater than or equal to 120 mg/dl indicates the need for a glucose tolerance test. Further, it was recommended that blood glucose values of all pregnant women should be measured between the 24th and 28th weeks of pregnancy. Several alternatives were also suggested. They recommended that a full glucose tolerance test be carried out on women with 1) plasma glucose values greater than or equal to 150 mg/dl 1 hour following 50 grams of oral glucose, or 2) capillary blood glucose values greater than or equal to 120 mg/dl 2 hours following administration of 75 grams of glucose, or 3) plasma glucose values greater than or equal to 140 mg/dl 2 hours following 100 grams of glucose. No specific time of day was recommended for these screening tests. In persons with a positive

TABLE 4. *Prevalence of gestational diabetes mellitus (GDM)*

Reference	Source Population and Location	Date of Study	Number of Pregnancies	Number Meeting Glucose Criteria	Prevalence Per 1,000 Pregnancies
a	Sequential prenatal registrants in Boston City Hospital. 76.5% participation rate for GTTs; nonparticipants checked with single blood glucose measurement. 60% white, 40% black; lower socioeconomic status; median age 24 years (range 13-44); median parity of 2; 9.6% with family history of diabetes; 52% of GTTs in the third trimester.	1964-65	752	19*	25
b	Community-based screening in Cleveland of women at 20-32 weeks of gestation; mean age 26 years.	1977			
	White		1,352	44**	33
	Nonwhite		855	25**	29
c	Pregnant women in second and third trimesters selected from obstetric prenatal clinics of LA County/UCLA Medical Center. None known to be diabetic; 2.7% of women with two fasting glucose values > 100 mg/dl were considered to be overt diabetics and are excluded.	1964-65			
	Mean age 24.3 years; mean gravida 3.5; none of the risk factors below		295	16***	54
	Mean age 25.8 years; family history of diabetes; mean gravida 4.4		218	28***	128
	Mean age 30.6 years; obstetric history (previous baby > 9 lbs., previous fetal death, toxemia, etc.); mean gravida 7.2		127	28***	220
	Total		640	72***	113
d	Reanalysis of 1964-65 Los Angeles data; 3.5% of women with fasting glucose > 100 mg/dl were considered diabetic and were excluded.	1964-65			
	Mean age < 20 years		134	5***	45
	Mean age 20-30 years		308	23***	97
	Mean age > 30 years		210	29***	209
	Total		652	57***	123

*Two or more venous whole blood glucose values greater than: fasting, 90 mg/dl; (after 100-gram glucose challenge): 1-hour, 165 mg/dl; 2-hour, 145 mg/dl; 3-hour, 125 mg/dl.

**Plasma glucose > 120 mg/dl 2 hours after 75 grams of glucose; criteria in previous footnote after 75 grams of glucose.

***Fasting venous whole blood glucose value less than 100 mg/dl; 2 of 3 values after 100-gram glucose challenge greater than: 1-hour, 170 mg/dl; 2-hour, 130 mg/dl; 3-hour, 120 mg/dl.

(Continued)

TABLE 4 (Continued)

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TABLE 5. *One-hour 50-gram glucose challenge as a screen for gestational diabetes mellitus (GDM)*

Reference	One-Hour Glucose Value	Number Screened	GDM* Present Number (Percent)	GDM Absent Number (Percent)
a	Blood glucose			
	≥ 130 mg/dl	109	15 (13.8)	94 (86.2)
	< 130 mg/dl	643	4 (0.6)	639 (99.4)
b	Plasma glucose			
	130-134 mg/dl	13	0 (0)	13 (100.0)
	135-142 mg/dl	31	4 (12.9)	27 (87.1)
	≥ 143 mg/dl**	65	20 (30.8)	45 (69.2)

*Diagnosis of GDM based on 3-hour 100-gram oral glucose tolerance test.

**Equivalent to blood glucose value ≥ 130 mg/dl.

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screening test but a negative glucose tolerance test, it was recommended that the oral glucose tolerance test be repeated at 32 weeks gestation. Only the first of the three suggested screening methods (the 50-gram glucose challenge) had source data that could be properly evaluated by examining the sensitivity and specificity rates in a random sample (Table 5).

Risk Factors For Development of GDM

Clinical history is an insensitive measure in selection of women at risk for GDM. In several studies, the incidence of GDM was no higher in patients selected on the basis of prior macrosomic infant, prior pregnancy loss, or positive family history of diabetes (O'Sullivan et al. 1973). Maternal age appears to be the single most reliable clinical correlate of abnormal GTT in pregnancy, with more abnormal tests occurring in older women (Macafee and Beischer 1974).

Only 44 percent of nondiabetic pregnant women have identifiable risk factors commonly used in screening for GDM. Among 18,812 prenatal patients registered at two Boston hospitals between 1954 and 1959, 56 percent did not have elevated venous blood glucose values (greater than 130 mg/dl 1 hour after a 50-gram glucose challenge), a family history of diabetes, previous adverse pregnancy history, or previous birth of a heavy baby (O'Sullivan et al. 1973). Testing only women age 25 years or older with historical risk factors resulted in 38 percent of gestational diabetics going unidentified, while a screening blood glucose of 130 mg/dl after 50 grams of glucose regardless of other risk factors identified 88 percent of gestational diabetics.

Among 1,921 consecutive women evaluated at their first prenatal clinic visit, the following purported risk factors for GDM were found: obesity (9.7 percent), glycosuria greater than or equal to 1+ (1.8 percent), family history (15.9 percent), previous large baby (2.6 percent), and poor obstetric history (4.8 percent). Of these factors, 10-12 percent of women with obesity or glycosuria had GDM, whereas only 2-4 percent of women with the other risk factors had GDM (Widness et al. 1980).

PROGNOSIS FOR THE DEVELOPMENT OF DIABETES AMONG PREGNANT WOMEN

The possibility that pregnancy precipitates diabetes or unmasks incipient diabetes is an intriguing question. Among 615 patients with GDM during 1954-60 followed for 22-28 years postpartum, 24.7 percent developed diabetes, which was 16 times the rate of women who had not had GDM (Table 6). The rate of developing IGT was 5.6-fold higher among women with GDM. Several factors in addition to GDM appeared to place women at higher risk for later development of diabetes. These included a history of perinatal mortality and birth of a heavy baby. Subsequent deterioration of glucose tolerance was also related to higher blood glucose levels exhibited during pregnancy (O'Sullivan 1980a, 1980b).

TABLE 6. *Incidence of diabetes and impaired glucose tolerance in 22-28 year followup of pregnant women with or without gestational diabetes (GDM) in 1954-60**

	Number	Percent
Diabetes		
With GDM	152/615	24.7
Without GDM	5/328	1.5
Impaired glucose tolerance		
With GDM	243/615	39.5
Without GDM	23/328	7.0

*National Diabetes Data Group criteria for diabetes and IGT; O'Sullivan and Mahan criteria for GDM (Table 3).

SOURCE: O'Sullivan, JB. Long-range implications of gestational diabetes for the mother. Presented at the Second International Workshop on Gestational Diabetes, Chicago, October 1984.

In the same study, GDMs who delivered a baby weighing more than 9 pounds showed more severe glucose intolerance subsequently than GDMs who delivered babies weighing less than 9 pounds. The prevalence of "decompensated diabetes" (any two of the following venous whole blood glucose values: fasting greater than or equal to 120 mg/dl, postprandial greater than 180 mg/dl, and greater than or equal to 300 mg/dl after 100 grams of oral glucose) was twice as great for GDMs bearing heavy babies as for GDMs bearing normal-weight babies. Among GDMs, development of more severe glucose intolerance was also associated with higher relative body weight, older age, family history of diabetes, and history of perinatal mortality. The study thus indicated that, in persons with transient hyperglycemia during pregnancy, these are risk factors for subsequent diabetes.

Of 181 patients with GDM, 23 (12.7 percent) developed elevated fasting plasma glucose (greater than 110 mg/dl) and 59 (32.6 percent) had an abnormal glucose tolerance test without fasting hyperglycemia when tests were repeated up to 5 years after delivery (Mestman et al. 1971). Age did not appear to be a factor in subsequent development of abnormal tests, but the prevalence of obesity was greater in women whose oral glucose tolerance tests became abnormal.

While prospective evidence is lacking, the available data favor the conclusion that pregnancy itself does not play a significant role in the causation or earlier appearance of diabetes. A cross-sectional survey in the United States in 1960-62 of women without diagnosed diabetes found that blood glucose levels 1 hour after ingesting 50 grams glucose did not change with increasing parity (Table 7). In a similar study in 1976-80 employing 75 grams glucose, the percent of women in each parity group did not differ significantly by their 2 hour plasma glucose levels (Table 8).

TABLE 7. *Parity and mean blood glucose levels (mg/dl) 1 hour after 50 grams glucose in women without a medical history of diabetes, United States, 1960-62*

	Parity					
Age (Years)	0	1	2	3-4	5-6	7-8
18-24	104	104	107	102	101	-
25-34	112	112	111	110	108	104
35-44	123	120	114	118	120	126
45-54	130	139	129	128	133	123
55-64	138	147	141	147	150	151
65-74	161	160	154	154	158	166

SOURCE: O'Sullivan, JB, and T Gordon. Childbearing and diabetes mellitus. NCHS Vital and Health Statistics Series 11, No. 18, August 1973.

OUTCOME OF DIABETIC AND GESTATIONAL DIABETIC PREGNANCIES

It is generally accepted that congenital malformations in the offspring of patients with insulin-dependent diabetes mellitus (IDDM) are about two to three times more common than among those of nondiabetic mothers (Kucera 1971, Naeye 1965, LM Pedersen et al. 1964). However, it is less certain that there is an increased risk for women with gestational diabetes. Most studies have found that perinatal mortality among offspring of gestational diabetic women is not significantly different from that of the nondiabetic population, which may be partly the result of treatment to normalize blood glucose levels in GDM patients (Hadden 1980, Roversi et al. 1979, Gyves et al. 1980).

TABLE 8. *Percent of women in four parity groups by plasma glucose values 2 hours after 75 grams glucose, United States, 1976-80*

	Parity				Mean Number of Children
	0	1	2-3	4+	
Age 20-34					
Diagnosed diabetics	22	26	47	4	1.7
Nondiabetics, glucose value					
≥200 mg/dl	-	-	-	-	-
140-199 mg/dl	36	10	48	5	1.5
<140 mg/dl	39	22	32	7	1.3
Age 35-54					
Diagnosed diabetics	8	12	42	39	3.5
Nondiabetics, glucose value					
>200 mg/dl	4	0	51	45	3.9
140-199 mg/dl	11	10	35	43	3.8
<140 mg/dl	10	9	47	34	3.1
Age 55-74					
Diagnosed diabetics	15	12	29	43	3.4
Nondiabetics, glucose value					
≥200 mg/dl	13	12	45	30	3.6
140-199 mg/dl	15	16	36	33	2.7
<140 mg/dl	17	13	46	25	2.7

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

MATERNAL COMPLICATIONS DURING DIABETIC PREGNANCY

There are few population-based data concerning the effects of diabetes on maternal morbidity. The increased insulin requirements and the greater proneness to ketoacidosis among diabetic women in pregnancy are well-recognized, manageable problems. Toxemia has been reported to occur in 20 percent of diabetic pregnancies, as compared with 4.4 percent of nondiabetic pregnancies; the comparable figures for hydramnios were 20.4 percent and 0.3 percent (Miller and Black 1964). The prevalence of hydramnios and toxemia, and its related components hypertension and renal disease, are generally higher in the diabetic pregnancy, although published data exhibit a very wide variation. The difficulty in detecting minor degrees of hydramnios clinically, and the differences in criteria used in the diagnosis of toxemia, contribute to the varied reported prevalence rates. However, advances in antenatal care have greatly reduced the frequency of such conditions. There are no adequate, controlled studies to provide a current assessment of the occurrence of these morbid conditions in diabetic and nondiabetic pregnancies. The increased incidence of fetal macrosomia in diabetic pregnancies imposes a greater likelihood of delivery by cesarean section, with attendant risk of infection and hemorrhage; the extent of this risk has not been quantified.

No differences in the prevalence or severity of retinopathy, nephropathy, or neuropathy were found between 22 IDDM women with one or two pregnancies and 22 IDDM women who had not experienced pregnancy (Carstensen et al. 1982). The two groups of women had been matched for age, duration of diabetes, insulin secretory capacity, blood glucose control, insulin requirement, social status, and body weight, because these factors themselves might influence development of complications.

Retinopathy, the most easily documented diabetic vascular lesion, has been studied in one controlled trial among pregnant diabetics (Maloney and Drury 1982). A group of pregnant IDDMs were selected from two Dublin, Ireland, obstetric hospitals in 1979-81. The control group of nonpregnant diabetic women of childbearing age was selected from the medical records of a diabetologist by a nurse who had no knowledge of the status of the patient's retinal vasculature; no further sampling details were provided. The pregnant patients were examined frequently, and detailed mapping and photography was included; it is unclear whether the controls received equivalent documentation. No differences in clinical characteristics existed between the two groups (Table 9). The severity of the individual components of diabetic retinopathy varied independently throughout the gestational period and indicated some accentuation of retinopathy during pregnancy. However, regression occurred postpartum, with return to control levels by 6 months postpartum (Table 9). Among another group of 51 pregnant

TABLE 9. *Diabetic retinopathy in pregnant and nonpregnant insulin-dependent diabetic patients*

	Pregnant Patients (N = 53)	Nonpregnant Patients (N = 39)
Clinical data*		
Age (years)	28.0 ± 0.6	28.5 ± 0.9
Duration of diabetes (years)	10.2 ± 0.8	9.5 ± 1.0
Age at onset (years)	17.8 ± 0.8	19.5 ± 1.1
Parity (number of pregnancies)	0.9 ± 0.2	1.2 ± 0.2
Insulin (units per day)	42.5 ± 2.2	47.0 ± 2.6
Contributory family history (%)	37	44
Smokers (%)	40	36
Use of contraceptive pill (%)	15	15
Retinopathy during pregnancy**	Number (Percent)	Number (Percent)
None	20 (38)	21 (54)
Background	30 (57)	17 (44)
Proliferative	3 (6)	1 (3)

*No significant differences in clinical characteristics between pregnant and nonpregnant patients. Means ± standard deviation, except percent data.

**During pregnancy 8 of 20 with no retinopathy developed background retinopathy, and 1 of 30 with background retinopathy developed proliferative changes. Six months after delivery, 24 of the 53 patients had no retinopathy, and neovascularization showed some regression.

SOURCE: Maloney, JB, and ID Drury. The effects of pregnancy on the natural course of diabetic retinopathy. Am J Ophthalmol 93:745-56, 1982.

diabetic women with retinopathy, deterioration also occurred during pregnancy but regressed postpartum (Singerman et al. 1980). For 41 women with background retinopathy, 85 percent progressed to a more severe stage during pregnancy, but three-fourths of these regressed to a less severe background disease. Of 10 women with proliferative retinopathy, 6 had progression after delivery.

Among diabetic women referred to an ophthalmologic clinic, 15 of 21 eyes (71 percent) with background retinopathy developed proliferative retinopathy during pregnancy as compared with 8 of 16 eyes (50 percent) in diabetic patients who did not become pregnant. However, long-term visual efficiency was almost equal in both groups. This study included patients who had had proliferative retinopathy but who had been treated with photocoagulation and were in the background retinopathy category at the time of pregnancy (Johnson 1980).

In a population-based sample of diabetic patients in Wisconsin, 397 women with IDDM (diagnosed as diabetic before age 30 years and using insulin) were studied for the relationship of pregnancy and retinopathy using stereoscopic fundus photographs. The number of pregnancies was positively associated with the severity of retinopathy, but when the duration of diabetes was considered this relationship was no longer apparent (Klein and Klein 1984). The effect of diabetes duration on the progression of retinopathy in pregnant diabetics has also been found in other studies (Dibble et al. 1982). The retinopathy-duration association appears to be the most important determinant of retinopathy, and the number of past pregnancies does not appear to adversely affect this risk.

MORTALITY AMONG PREGNANT DIABETIC WOMEN

Maternal mortality in both diabetic and nondiabetic pregnancies is now extremely rare. Among all pregnancies in the United States in 1980, maternal death during pregnancy or delivery occurred in only 334 women (9.2 deaths per 100,000 live births). The leading cause of maternal death was complications from ectopic pregnancy; about one in every 40 pregnancies was ectopic. Among the 372 deaths that occurred in women during pregnancy and childbirth in 1978, only one was coded as diabetes on the death certificate (Harris 1978). However, remarkably little factual evidence exists to confirm that the maternal mortality rate in diabetics is no different from that of nondiabetics. The major problem is the unavailability of a credible denominator. Commonly cited figures have been 0.03-0.07 percent for pregnant diabetics as compared with 0.032-0.037 percent for the general population. A rate of 0.5 percent, which is 60 times higher than that for the general obstetric population, has been cited without providing the source data (Gabbe et al. 1976). Alternatively, another study indicated no maternal deaths in 600 diabetic pregnancies (Drury et al. 1977).

Among 144 diabetic women with established vascular disease seen at the Joslin Clinic from 1924 to 1962, 271 pregnancies occurred. A 1971 followup reported that 32 of these women had died; their mean survival after pregnancy was 8 years (White 1971). One vascular complication may carry substantial risk for maternal mortality, namely, preexisting ischemic heart disease. Although the number of reports in the literature is small, those that exist suggest a high mortality among diabetic mothers with ischemic heart disease (Hare and White 1977). Whether this risk applies to all women or just to diabetic women is not certain.

BIRTH CONTROL MEASURES IN DIABETIC WOMEN

Contraceptive Use

In the 1976-80 National Health and Nutrition Examination Survey (NHANES II) of a representative sample of the United States population, 9.6 percent of diabetic women ages 15-44 years were using an oral contraceptive. This was about one-half the rate of nondiabetic women (Table 10). Almost equal proportions of diabetic and nondiabetic women had used the pill in the previous 6 months but had discontinued use. Increased risk of venous thrombophlebitis and thromboembolism, myocardial infarction, stroke, lipid alterations, and hypertension have been reported for oral contraceptive users; the risks for diabetic women have not been documented.

Among 276 insulin-dependent diabetic patients in Scotland, 11 of 30 (37 percent) became pregnant within 1 year of insertion of an intrauterine device; the failure rate for this form of contraception is generally between 2 and 4 per 100 women per year (Steel and Duncan 1980). Among 69 patients using mechanical contraceptive methods (diaphragm, condom), 6 became pregnant.

TABLE 10. *Percent of diabetic and nondiabetic women ages 15-44 years using the oral contraceptive pill*

	Diabetic* Women	Nondiabetic** Women
Currently using the pill	9.6	19.6
Not currently using the pill, but used within the past 6 months	5.4	6.7
Total	15.0	26.3

*Reported in a medical history interview that a doctor had told them they had diabetes.

**No medical history of diabetes reported in a medical history interview.

SOURCE: Russell-Briefel, R. Analyses of the 1976-80 National Health and Nutrition Examination Surveys, National Center for Health Statistics.

Abortion

In 1980, 359 induced terminations of pregnancy occurred for every 1,000 live births (Burnham 1983); the number and rate among diabetic women are unknown.

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APPENDIX A. *Fetal and maternal survival experience of Joslin Clinic patients*

Year	Number of Cases	Fetal Survival (Percent)	Maternal Survival (Percent)
1898-1917	10	40	66
1924-1938	128	54	-
1938-1958	900	86	-
1958-1974	1,119	90	-
1975	75	94	100

SOURCE: Hare, JW, and P White. Pregnancy in diabetes complicated by vascular disease. Diabetes 26:953-5, 1977.

APPENDIX B. *Incidence of diabetes per 1,000 women in single women and in married women by parity, Birmingham, England, 1949-58*

Age at Diagnosis (Years)	Single Women	Married Women - Parity					
		0	1	2	3	4-5	6+
45-49	4.4	3.8	3.6	5.1	5.3	10.1	21.6
50-59	7.9	6.6	7.3	10.8	14.4	26.2	47.1
60-69	9.1	9.8	12.9	16.4	21.8	30.1	45.8
70-79	7.8	7.1	9.7	8.7	15.5	24.7	45.0
80-89	1.9	2.0	5.6	4.4	5.3	4.7	9.3

SOURCE: Fitzgerald, MG, JM Malins, DJ O'Sullivan, and M Wall. The effect of sex and parity on the incidence of diabetes mellitus. Q J Med 30:57-70, 1961.

CHAPTER XXI. THE INFANT OF THE DIABETIC MOTHER

James L. Mills, M.D., and John B. O'Sullivan, M.D.

SUMMARY

Infants of diabetic mothers are at risk for many problems. In recent population-based studies, perinatal death occurred in 4 to 8 percent of diabetic pregnancies. Similar rates occurred at referral hospitals in the United States. This rate was two to four times higher than in nondiabetic pregnancies, although at tertiary care centers the ratio may be lower. About 5 to 10 percent of infants of diabetic mothers had major congenital anomalies at birth, about one-third of which were fatal. Indeed, fatal congenital anomalies appear to be the leading cause of death among these infants. Macrosomia is about twice as frequent in offspring of diabetic mothers, and these infants are also at high risk for low blood glucose and calcium levels, respiratory distress, and jaundice. Improved diabetic care during pregnancy, closer monitoring of the fetus, and vigorous management of the infant after delivery may explain the marked improvement in prognosis for the infant of the diabetic mother over the past several decades.

INTRODUCTION

For many years, physicians have recognized that birth is fraught with danger for the infant whose mother has diabetes. As long ago as 1885, an association between diabetes and congenital malformations was recognized (Le Corche 1885). Before insulin was commercially available, few infants survived. For example, between 1898 and 1917, among Joslin Clinic patients, only 40 percent of viable fetuses and only 66 percent of mothers survived (Hare and White 1977). With the advent of insulin treatment, maternal survival improved dramatically, but a host of new risks to the infant were uncovered. Stillbirth became alarmingly frequent, and in order to prevent death in utero, infants were deliberately delivered prematurely. Many of these died of respiratory distress or other complications of prematurity. More recently, hypoglycemia, hypocalcemia, hyperbilirubinemia, macrosomia, and polycythemia have been added to the list of problems for infants of diabetic mothers.

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Fortunately, as new risks were identified, more aggressive monitoring and management were instituted to combat them. Currently, the risk of dying during pregnancy is no greater for the diabetic woman than for any other woman. While the situation is not as clear where the infant is concerned, the infant's risk of death has certainly been reduced. Many factors may have contributed to the improved outlook for infant survival: vigorous control of diabetes, prenatal monitoring, improved timing of delivery, and neonatal intensive care. Congenital malformations are now the leading cause of death in some clinical centers (Soler 1976); at these centers, except for deaths due to congenital malformations, the death rate of infants of diabetic mothers appears to be no higher than that of the general hospital population (Lemons et al. 1981). However, in population-based studies, the perinatal death rate of infants of diabetic women is two to four times greater than the rate of infants of nondiabetic women.

PROBLEMS IN INTERPRETATION OF DATA

There are certain limitations in the extant data on pregnancy outcome in diabetic women. Although three population-based studies that yield data on a representative sample of diabetic pregnancies have recently been conducted, no standard rigorous definitions of diabetes could be employed in these studies. Fetal death certificates report only about 80 percent of maternal diabetes, and birth certificates report only about 22 percent (Wheeler et al. 1982). Most data have come from hospital case series, but these pregnancies may not be representative of the general diabetic population because some include gestational diabetic patients and some do not. In addition, some exclude deaths in "pre-viable" infants. Such problems make the reported rates difficult to interpret.

For morbidity, the situation is even worse. Morbidity statistics cannot be population-based, since infants cannot be tested in the same way. Case series from different institutions are difficult to compare, because they rarely state how morbidity was identified or defined, or describe the completeness of ascertainment. For example, were all infants checked for hypoglycemia and how often? If not all subjects were checked, artificially low rates could result. Rates among institutions cannot be compared unless the definition of disease is the same; if one institution defines hyperbilirubinemia as greater than 10 mg/dl and another as greater than 15 mg/dl, the rates will not be comparable. Finally, the population in one hospital may differ from the population in another.

The bias that can potentially be introduced by studies of pregnancy in specialized referral-center hospitals is shown in Tables 1 and 2. While 36 percent of all diabetic pregnancies were delivered in tertiary care centers, only 19 percent of pregnancies not complicated by diabetes were delivered in such centers (Table 1). Fetal and neonatal death rates in diabetic pregnancies differed among three types of hospitals, as did the proportion transferred to other medical facilities and for which hypoglycemia was reported (Table 2). In addition, there is further variation in location of delivery by type of diabetes in the mother, which may contribute additional bias to assessment of the outcome of diabetic pregnancies (Table 1).

TABLE 1. *Percent of diabetic and nondiabetic pregnancies delivered in tertiary care centers and other hospitals, Washington State, 1979-80*

Maternal Diabetes	Tertiary Care Hospitals	Large Hospitals	Small Hospitals
IDDM	39	49	12
NIDDM	26	50	24
Gestational	33	46	22
Total diabetes	35	48	18
Nondiabetic	19	53	28

SOURCE: Washington State Diabetes Control Program. Diabetes Update, CDC, Vol. 4, No. 1, March 1983.

TABLE 2. *Location of delivery and characteristics of deliveries of diabetic women, Washington State, 1979-80*

Delivery Characteristics	Tertiary Care Hospitals	Large Hospitals	Other Hospitals
Percent of deliveries of overtly diabetic women	36	48	16
Percent transported to other medical facilities	2.3	11.1	10.4
Percent with hypoglycemia detected	41.8	39.6	27.9
Percent with no test for hypoglycemia reported	3.3	5.8	14.0
Fetal deaths/1,000 pregnancies	24.0	88.6	96.2
Neonatal deaths/1,000 live births	48.0	31.6	19.2
Perinatal deaths/1,000 pregnancies	62.5	120.3	115.4

SOURCE: Washington State Diabetes Control Program. Diabetes Update, CDC, Vol. 4, No. 1, March 1983.

FETAL MORTALITY

Population-Based Studies

In the United States in 1981, the fetal death rate for all pregnancies was 9.0 per 1,000 live births. In several population-based studies, the rate for diabetic pregnancies was three to eight times higher (Table 3). Detailed information from hospital charts of mothers and infants and from birth and fetal death certificates was obtained in 674 diabetes-complicated pregnancies and over 900 nondiabetic pregnancies occurring in Washington State in 1979-80. The fetal death rate for nondiabetic pregnancies was 7.3 per 1,000 live births, but was 2.2 times higher for women with gestational diabetes, 7.7 times higher for women with insulin-dependent diabetes, and 12.7 times higher for women with noninsulin-dependent diabetes (Table 3). Similar data sources were used in South Carolina in 1978, where the diabetic fetal death rate was 8.2 times higher than the nondiabetic rate. In Washington State, a 2.2-fold higher rate was found for women with gestational diabetes. There is an excess of fetal deaths in diabetic pregnancies with gestational age greater than or equal to 35 weeks: among 74 fetal deaths in diabetic pregnancies in Michigan and Mississippi in 1975-77, 65 percent occurred after 35 weeks' gestation, whereas only 47 percent of fetal deaths in nondiabetic pregnancies occurred at an estimated gestational age of 35 weeks or later (CDC 1980).

TABLE 3. *Population-based studies of perinatal mortality in the United States and in diabetic and nondiabetic pregnancies*

Reference	Source Population and Year	Number	Rate Per 1,000 Live Births
a	U.S.; all deliveries in 1981		
	Fetal	32,596	9.0
	Neonatal (<28 days)	29,121	8.0
	Total perinatal	61,717	17.0
	Infant (<1 year)	43,305	11.9

Reference	Source Population and Year	Rate Per 1,000 Live Births		Relative Risk From Diabetes
		Maternal Diabetes	No Maternal Diabetes	
b	Upstate New York; white women only; 1958-69	187.5	25.4	7.4
b	Michigan; 1975-76	63.2	16.8	3.8
	White	59.8	14.6	4.1
	Nonwhite	76.2	24.6	3.1
b	Illinois; 1975-76	81.8	-	-
c	All fetal deaths and deaths among live births in South Carolina; maternal diabetes identified on vital records and hospital discharge record; 49% nonwhite; 1978			
	Fetal	105.2 (28/266)	12.9 (636/49,292)	8.2
	Neonatal	7.5 (2/266)	-	-
	Total perinatal	112.8 (30/266)	25.3	4.4
d	Same South Carolina studyin 1980; 31% identified as gestational diabetics			
	Fetal	63.0 (24/381)	-	-
	Neonatal	18.4 (7/381)	-	-
	Total perinatal	81.4 (31/381)	22.3	3.5
	Total perinatal diabetics	111.5	-	-
	Total perinatal gestational diabetics	7.9	-	-
e	Sample of diabetic and nondiabetic pregnancies in Washington state; review of hospital charts to determine maternal diabetes; 1979-80			
	Fetal deaths	IDDM: 56.1 (17/286)	7.3 (7/965)	7.7
		NIDDM: 92.6 (5/49)	-	12.7
		GDM: 15.8 (5/312)	-	2.2
	Neonatal deaths	IDDM: 42.0 (12/286)	6.9	6.1
		NIDDM: 0 (0/49)	-	-
		GDM: 16.0 (5/312)	-	2.3

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NEONATAL MORTALITY

Population-Based Studies

Neonatal mortality, defined as death within 28 days of live birth, occurred in 8.0 per 1,000 live births in the United States in 1981. Among diabetic pregnancies, the rate was 6.1 times higher among infants of insulin-dependent women in Washington State in 1979-80 (Table 3). This study also found a 2.3-fold higher rate among infants of women with gestational diabetes.

PERINATAL MORTALITY

Population-Based Studies

Among all pregnancies in the United States in 1981, perinatal mortality (the sum of fetal and neonatal mortality) occurred in 17.0 per 1,000 live births. In population-based studies, the rate among diabetic pregnancies was 2- to 7-fold higher (Table 3).

Case Series

As discussed above, case series reports of perinatal mortality in infants of diabetic mothers have several disadvantages: they are not population-based, they may exclude some types of diabetes, e.g., gestational, and their rates have wide confidence limits. Nonetheless, they are of interest because they include diabetes-specific mortality, give a general idea of the increased risk faced by infants of diabetic mothers, and allow some comparisons among institutions. Table 4 compiles pertinent case series, including one report covering a large segment of the Irish population and several reports from regional United States hospitals, which include a large proportion of diabetic deliveries in their geographic area. When the study covered a long time period, the most recent survival rates were generally better. For example, in Denmark the perinatal mortality rate declined from 22.1 percent in 1946-55 to 4.4 percent in 1976-78 (Molsted-Pedersen 1980). Whenever possible, the population has been characterized by White classification to aid in interpreting reported mortality. These data on diabetic pregnancies might be compared to all deliveries in the United States, in which 1.2 percent resulted in death under 1 year of age, one-fifth of which were attributed to congenital anomalies (Table 4).

CONGENITAL MALFORMATIONS IN INFANTS OF DIABETIC MOTHERS

Population-Based Studies

There are no entirely satisfactory reports of malformation rates in infants of diabetic mothers. Nondiabetic populations examined with the same care as diabetic populations are generally lacking, and, in the two population-based studies, the definition of congenital malformations has not been provided. In these two studies, the incidence of congenital malformations appears to be higher in diabetic pregnancies, but the actual rate in the nondiabetic population was not reported (Table 5).

TABLE 4. *Perinatal mortality in the United States, 1981, and among case series of infants of diabetic mothers, 1951-80*

Reference	Study Population, White Classification, Year	Number of Pregnancies	Percent (and Number) of Deaths	Percent (and Number) of All Births With Deaths Due to Malformations
United States				
a	All pregnancies in U.S.; fetal and neonatal deaths; 1981	3.63 million	1.70 (61,717)	-
a	All pregnancies in U.S.; infant deaths under 1 year; 1981	3.63 million	1.19 (43,305)	20.6 (8,914)
b	Regional hospital; 54 class A; death rate for classes B-R=14.8%; all neonatal deaths from respiratory distress syndrome; 1968-77	202	12.4 (25)	1.0 (2)
c	Referral hospital; 60% class A, 18% class B, 7% class C, 15% classes D, F, R; 1969-76	225	6.2 (14)	1.3 (3)
d,e	Referral hospital; classes B-R; 1971-75	260	4.6 (12)	1.5 (4)
f	Referral hospital; 68 gestational diabetes; 1974-75	96	4.2 (4)	-
g	Referral hospital; 9% class A, 91% classes B-R; 1975-76	147	3.4 (5)	2.7 (4)
h,i	Referral hospital; 17 class AB, 15 class B, 20 class C, 9 class D, 12 class F; 1975-79	74	4.1 (3)	2.7 (2)
j	Regional hospital; 57 gestational diabetes; 1978-80	110	10.0 (11)	4.5 (5)
Outside United States				
k	Large obstetrical hospitals in Ireland; approximately 20% of all Irish deliveries; no therapeutic abortion or sterilization; 1951-76	558	9.5 (53)	1.8 (10)
l	Referral hospitals in Denmark; stillbirths plus deaths in first 10 days of life; classes A-F; 1976-78	294	4.4 (13)	-
m	Referral hospital in England; classes A-F	100	6.0 (6)	4.0 (4)
n	Referral hospital in Italy; 237 class A; 43 class AB; 65 class B, 28 class C, 106 classes D-F; 484 offspring; 1963-75	479	2.9 (14)	0.8 (4)
o	Referral hospital in South Africa; all were juvenile-onset insulin-dependent patients; 1974-80	38	7.9 (3)	5.3 (2)

(Continued)

TABLE 4. (Continued)

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Case Series

Rates of major and fatal malformations in recently reported case series are summarized in Table 5, but, because the sample size is generally small, the rates have wide confidence intervals. In these studies, there is no uniformity in the definition of a malformation. Generally, major malformations were more consistently diagnosed and better defined than minor ones. Fatal malformations were the least likely to be overlooked. In general, malformations occurred in 4-10 percent of infants, with about one-third of these resulting in death. Among all deaths under age 1 year occurring in the United States in 1981, 21 percent were due to congenital anomalies (NCHS 1983).

Risk of Malformations by White Classification

Most studies show increasing risk of malformations with poorer White classification, but the number of subjects on which this is based is small (Table 6). Women with gestational diabetes (Class A) are not believed to be at increased risk, and these studies confirm a lower risk for this group.

TABLE 5. *Incidence of major congenital malformations in infants of diabetic mothers, 1926-80*

Reference	Study Population and Year	Number of Infants	Percent (and Number) with Major Anomalies	Percent (and Number) with Fatal Anomalies
Population-Based Studies				
a	All live births in South Carolina; 1978 and 1980	647	1978: 5.6 (15/266) 1980: 10.8 (41/381)	-
b	Sample of all diabetic and nondiabetic pregnancies in Washington State; 1979-80	-	Relative risk for diabetics versus nondiabetics = 6	-
Case Series - United States				
c	Referral hospital; 1969-76	217	4.6 (10)	1.4 (3)
d,e	Referral hospital; 1971-75	260	7.3 (19)	1.5 (4)
f	Referral hospital; excludes three anencephalic fetuses; 5% had minor anomalies; 1975-76	147	8.8 (13)	2.7 (4)
g,h	Referral hospital; 1975-79	74	8.1 (6)	2.7 (2)
i	Regional hospital; all diabetic deliveries; 1978-80	110	10.0 (11)	4.5 (5)
Case Series - Outside United States				
j	Large obstetric hospitals in Ireland; over 20% of all Irish deliveries; viable infants only; 1951-76	558	6.5 (36)	1.8 (10)
k	Denmark 1926-78	2,041	7.6 (156)	-
l	English hospital	100	9.0 (9)	4.0 (4)
m	Italian hospital; four minor malformations; 1963-75	484	2.3 (11)	0.6 (3)
n	South African center; 1974-80	38	7.9 (3)	5.3 (2)

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Risk of Malformations by Maternal Diabetic Control

Development of fetal organs during the first trimester is believed to be the crucial time for occurrence of malformations (Mills 1979). Level of glycosylated hemoglobin during the first 14 weeks of pregnancy is strongly correlated with the incidence of major congenital malformations. Among 58 diabetic women with HbA1c less than 8.5 percent during this period, only two offspring (3.4 percent) had a major congenital anomaly, while among 58 diabetic women with HbA1c levels greater than 8.5 percent, 22.4 percent of offspring had major congenital anomalies (Miller et al. 1981).

A significantly lower malformation rate was also found in 127 diabetic women who registered for care before pregnancy, compared to 270 women who registered after 8 weeks of gestation (Fuhrmann et al. 1983). The congenital malformation rate was 0.8 percent in the former group, but was 7.5 percent in the latter group. While there are important differences between women who register early for care and those who register later, these data support a role for good control in reducing the risk of malformation.

METABOLIC PROBLEMS AND OTHER ABNORMALITIES IN INFANTS OF DIABETIC MOTHERS

Hypoglycemia

Hypoglycemia in infants is of particular interest because of the possibility that it is the result of poor maternal diabetic control and could be prevented if control were improved. Case studies of diabetic patients and of two population-based samples of pregnancies are shown in Table 7. The definition of hypoglycemia in infancy remains controversial, and some of the differences seen in Table 7 could result from different definitions. Most hypoglycemic infants have subtle symptoms, if any; if infants are tested only when symptomatic, many cases of hypoglycemia will be missed, resulting in underreporting of this condition. Although the result of this may have been that hypoglycemia was detected in only 1.3 percent of offspring of nondiabetic mothers in the Washington State study, it is likely that the rate among infants of nondiabetic mothers is indeed significantly lower than the rate detected in offspring of diabetic mothers.

TABLE 6. *Major congenital malformation rates in infants of diabetic mothers by White classification, case series, 1926-80*

		Percent (and Number) of Malformed Children by White Classification					
Reference	Study Population and Year	A	B	C	D	F	R
United States							
a	U.S. referral hospital; 1969-76	3.1 (4/131)	5.0 (2/40)	0 (0/14)	11.0 (2/19)	20.0 (2/10)	0 (0/3)
b,c	U.S. referral hospital; 1971-75	-	5.8 (11/190)	7.9 (3/38)	{ 15.6 (5/32) }		
d	U.S. referral hospital; 1975-76	0 (0/13)	0 (0/30)	10.5 (6/57)	16.2 (6/37)	12.5 (1/8)	0 (0/2)
e	U.S. regional hospital; 1978-80	4.7 (2/43)	10.0 (5/50)	23.1 (3/13)	25 (1/4)	-	-
Outside United States							
f	Swedish hospital obstetric clinic; 1961-70	0 (0/20)	8.2 (4/49)	8.3 (5/60)	23.8 (10/42)	{ 11.1 (1/9) }	
g	English referral hospital	0 (0/16)	2.6 (1/39)	20.0 (5/25)	{ 15.0 (3/20) }		-
h	Danish hospitals; 1926-78	4.1 (17/415)	5.9 (29/486)	5.2 (23/443)	11.4 (67/586)	18.0 (20/111)	-

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TABLE 7. *Hypoglycemia in infants of diabetic mothers, 1969-80*

Reference	Study Population and Years	Definition of Hypoglycemia and Method of Detection	Percent Hypoglycemic	Comments
Population-Based Studies				
a	All deliveries in South Carolina; 1978	Review of infant's hospital chart; definition not stated	12.8 (34/260)	Review of mother's hospital chart to determine presence of maternal diabetes
b	All deliveries in South Carolina; 31% were gestational diabetics; 1980	Same as above	23.1 (88/381)	Same as above
c	Sample of diabetic and nondiabetic pregnancies in Washington State; 1979-80	Blood glucose <30 mg/dl; method not stated; review of infant's hospital chart	IDDM: 39.7 NIDDM: 33.3 GDM: 14.0 Nondiabetics: 1.3	Review of mother's hospital chart to determine presence and type of diabetes
Case Series - United States				
d	Regional hospital; 1969-76	Blood glucose <30 or <40 mg/dl; glucose oxidase and/or Dextrostix	<30 - 24 <40 - 31	Hypoglycemia more common in large-for-gestational-age infants (21/25) and preterm average-for-gestational-age infants (11/47)
e,f	Referral hospital; 1971-75	Serum glucose <30 mg/dl, or <20 mg/dl in infants under 2,500 grams; method not stated	31	
g	Referral hospital; 1975-76	Blood glucose <30 mg/dl at any age; routine measurement at 1,2,3,6,12,24, 36,48 hours	47	Well infants fed at 1 hour; sick infants and those <2 kg given IV glucose; hypoglycemia rare in preterm infants on IV, but common in large-for-gestational-age infants
h	Referral hospital; 1975-79	Whole blood glucose <30 mg/dl; measured every 30 minutes for first 2 hours; Dextrostix	18	Hypoglycemia more common when mothers had mean glucose levels >120 mg/dl in third trimester; all infants were asymptomatic
i	Regional hospital; 1978-80	Serum glucose <30 mg/dl; method not stated	Approx. 25	
Case Series - Outside United States				
j	Referral hospital, South Africa; 1974-80	Blood glucose <25 mg/dl within first 48 hours; method not stated	13	
k	Referral hospital, England	Blood glucose <30 mg/dl; measured at 2,4,6,12,18,24,30, 36,42,48 hours, or for symptoms of hypoglycemia; Dextrostix with glucose oxidase confirmation on capillary blood	19	5% symptomatic infants; hypoglycemia rates in infants of well-controlled diabetic women (20%) no different from rates in less controlled women (18%) but lower in whomen who were not hyperglycemic on day of delivery

(Continued)

TABLE 7. (Continued)

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Macrosomia

Among all deliveries in the United States in 1981, 10.4 percent of live offspring weighed 4,000 grams or more. In two population-based studies, macrosomia was about twice as frequent in diabetic pregnancies (Table 8). Case series have only occasionally provided valid comparison rates for nondiabetic pregnancies, but, when provided, the rate in diabetic pregnancies is also higher than the nondiabetic rate. Macrosomia is believed to be the result of poor maternal diabetic control during pregnancy. One case series showed the same relationship between large-for-gestational age (LGA) and hyperbilirubinemia.

Hypocalcemia

Not all reports indicate whether serum calcium was measured in all infants or how often. Differences in the frequency of measurement probably are not enough to account for the wide range of rates shown in Table 9. Gestational age at delivery may influence the risk of developing hypocalcemia.

Polycythemia

Relatively few reports mention polycythemia, perhaps because it is relatively uncommon, and virtually no reports discuss how polycythemia was sought. It is surprising that this hazardous condition does not receive more attention. Four studies are summarized in Table 9.

TABLE 8. *Macrosomia (large for gestational age, LGA) in the United States, 1978, and in infants of diabetic and nondiabetic mothers, 1963-80*

Reference	Study Population and Year	Definition of Macrosomia	Percent (and Number) With Macrosomia	Comments
a	3.035 million deliveries in U.S.;1978	>4,000 grams	All live births: 10.4 (313,058)	
Population-Based Studies				
b	Random sample of U.S. population (NHANES II); reported medical history of diabetes; OGTT results (NDDG criteria) for remainder; reported birth weight; ages 20-44; 1976-80	>9 lbs.	Medical history diabetes: 22.5 Undiagnosed diabetes: 9.1 IGT: 6.4 Normal: 7.2	
Case Series - United States				
c	Referral hospital; 1969-76	Criteria of Lubchenko	35.5 (77/217)	High rate of LGA believed to be due to suboptimal diabetic control
d,e	Referral hospital; 1971-75	>4,000 grams	Diabetics: 22.3 (58/260) All live births: 9.0	Macrosomia in diabetic women higher (p<.005) than general hospital rate
f	Referral hospital; 1974-75	>4,000 grams	Diabetics: 10.4 (10/96) All live births: 5.3	
g	Referral hospital; 1975-76	>90th percentile of weight of 8,000 infants born at the hospital	36.1 (53/147)	Macrosomic infants were most common in White classes B-D; birth weight was correlated (r=.35, p<.01) with mean maternal glucose value
h	Referral hospital; 1975-79	>4,090 grams	10.8 (8/74)	All macrosomia occurred in White classes B and C; majority of women had mean glucose >120 mg/dl in third trimester
i	Regional hospital; 1978-80	>90th percentile of weight for gestational age	29.1 (32/110)	
Case Studies - Outside United States				
j	English referral hospital	>90th percentile by Gairdner and Pearson criteria	16.0 (16/100)	LGA infants had significantly higher incidence of hyperbilirubinemia
k	Italian referral hospital; 1963-75	>4,000 grams	3.3 (16/484)	Most LGA infants' mothers came for care late in pregnancy
l	South African referral hospital; 1974-80	>90th percentile of weight for gestational age	13.2 (5/38)	Virtually no excess of LGA infants

(Continued)

TABLE 8. (Continued)

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Hyperbilirubinemia

Rates in seven case studies are shown in Table 10. However, as noted in the general comments, rates are influenced greatly by the definitions of disease. Since the definition of hyperbilirubinemia was not well established and since measurements were not performed in a consistent manner in these studies, rates are not comparable. In one report, the incidence of hyperbilirubinemia was compared in infants of diabetic mothers and gestational age-matched controls, excluding sick infants (Peevy et al. 1980). Large-for-gestational-age infants of diabetic mothers had higher bilirubin and carboxyhemoglobin levels at 60 hours than infants of nondiabetic mothers, but average-for-gestational-age infants of diabetic mothers did not.

TABLE 9. *Hypocalcemia and polycythemia among infants of diabetic mothers, 1969-76*

Reference	Study Population, Criteria, Year	Percent (and Number) of Infants with Hypocalcemia	Percent (and Number) of Infants with Polycythemia
a	U.S. referral hospital; serum calcium <7 mg/dl; venipuncture hematocrit >65% or capillary >75%; 1969-76	12.0 (26/217)	10.6 (23/217)
b,c	U.S. referral hospital; serum calcium <7 mg/dl; central venous hematocrit ≥65%; 1971-75	12.7 (41/322)	8.4 (27/322)
d	U.S. referral hospital; serum calcium measured at 6, 12, 24, and 48 hours; hypocalcemia (<7 mg/dl) was not associated with hypoglycemia or large-for-gestational-age; 1975-76	22.4 (33/147)	-
e	English referral hospital; calcium measured daily; hypocalcemia (<7.2 mg/dl) significantly (p <.01) more common in infants delivered before 37 weeks' gestation; hematocrit >65%	8.0 (8/100)	3.0 (3/100)
f	South African referral hospital; hematocrit measured as necessary; hematocrit >65%; 1974-80	-	5.3 (2/38)

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Respiratory Distress Syndrome

Rates of respiratory distress syndrome (RDS) in population-based and hospital-based studies are shown in Table 11. There are differences in the definition of RDS. Rates of RDS are generally similar among the case series but are higher in the more population-based hospital study of McFarland and in Washington State and South Carolina, which could have included subjects who received less sophisticated care. In addition, in the McFarland study in a regional hospital, average gestational age was somewhat lower than in the other case series and the definition of RDS was somewhat broader. Several groups reported RDS in cases where L/S ratios indicated mature lungs.

TABLE 10. *Hyperbilirubinemia among infants of diabetic mothers, 1969-80*

Reference	Study Population, Criteria, Year	Bilirubin Criteria and Comments	Percent (and Number) of Infants with Hyperbilirubinemia
a	U.S. referral hospital; 1969-76	>12 mg/dl within 5 days in term infants; >15 mg/dl within 7 days in preterm infants	15.7 (34/217)
b,c	U.S. referral hospital; 1971-75	>10 mg/dl	36.6 (118/322)
d	U.S. referral hospital; 1975-76	>15 mg/dl; measured at 24 and 48 hours; intervention by phototherapy probably prevented other infants from reaching levels >15 mg/dl	19.0 (28/147)
e,f	U.S. referral hospital; 1975-79	"Jaundice requiring phototherapy"; the neonatal unit determined which infants received phototherapy	9.5 (7/74)
g	U.S. regional hospital; 1978-80	>5 mg/dl; method of screening not reported	Approximately 60
h	English referral hospital	>15 mg/dl; bilirubin measured daily in all subjects; hyperbilirubinemia more common in large-for-gestational-age infants	19.0 (19/100)
i	South African referral hospital; 1974-80	>10 mg/dl; bilirubin measured "if necessary"	18.4 (7/38)

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TABLE 11. *Respiratory distress syndrome (RDS) in infants of diabetic mothers, 1971-80*

Reference	Study Population and Year	Definition of RDS	Percent (and Number) with RDS	Comments
Population-Based Studies				
a	All deliveries in South Carolina; 1978	Review of infant's hospital chart; definition not stated	16.9 (45/266)	Review of mother's hospital chart to determine presence of maternal diabetes
b	All deliveries in South Carolina; 1980	Same as above	10.5 (40/381)	Same as above
c	Sample of diabetic and nondiabetic pregnancies in Washington State; 1979-80	Assisted ventilation; review of infant's hospital chart	IDDM: 25.0 (68/272) NIDDM: 20.4 (10/49) GDM: 8.3 (25/302) Nondiabetics: 4.1 (31/752)	Review of mother's hospital chart to determine presence and type of maternal diabetes
Case Series - United States				
d	Referral hospital; 1969-76	Clinical course, oxygen requirement >40% for >72 hours, plus X-ray findings	2.8 (6/217)	Five delivered at 28-34 weeks' gestation; one at 38 weeks with L/S ratio of 2.7
e,f	Referral hospital; 1971-75	Not stated	6.2 (16/260)	Mean gestation of 37.9 weeks
g	Referral hospital; 1975-76	Based on oxygen and ventilation required; respiratory rate >60; typical X-ray findings; clinical signs	7.6 (11/145)	Four delivered at 37-39 weeks' gestation; 12% with L/S ratios of 2-3 developed RDS
h,i	Referral hospital; 1975-79	Not stated	2.7 (2/74)	No deaths; one with L/S ratio = 2.1
j	Regional hospital; 1978-80	Oxygen or other respiratory assistance	28.2 (31/110)	One premature died of RDS; 2 required CPAP; 3 ventilators; average gestational age of White classifications B-D = 36 weeks
Case Series - Outside United States				
k	English referral hospital	Characteristic X-ray and clinical findings	9.0 (9/100)	Three required ventilation; one death; 8.6% with L/S ratios >2.0 developed RDS
l	South African referral hospital; 1974-80	Respiratory rate >60; retractions, grunting, cyanosis, typical X-ray findings	5.3 (2/38)	One death associated with RDS

(Continued)

TABLE 11. (Continued)

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APPENDIX A. *Neonatal and infant mortality rates per 100,000 live births, United States, 1981*

Age and Cause of Death	ICD Number	Mortality Rate Per 100,000 Live Births
Total, under 1 year		1,193.2
Under 28 days		802.4
28 days to 11 months		390.8
Certain gastrointestinal diseases	008-009,535,555-558	7.7
Pneumonia and influenza	480-487	22.3
Congenital anomalies	740-759	245.6
Disorders relating to short gestation and unspecified low birthweight	765	100.8
Birth trauma	767	25.3
Intrauterine hypoxia and birth asphyxia	768	38.7
Respiratory distress syndrome	769	119.0
Other conditions originating in the perinatal period	760-764,766,770-779	308.9
Sudden infant death syndrome	798.0	145.9
All other causes	Residual	179.0

SOURCE: Annual Summary, 1983. NCHS Monthly Vital Statistics Report, Vol. 32, No. 13, September 21, 1984.

APPENDIX B. *Perinatal mortality, by admission blood glucose levels, South Carolina, 1980*

Glucose (mg/dl)	Number	Percent	Perinatal Deaths Per 1,000 Deliveries
Diabetics			
1-59	15	3.7	133.3
60-100	127	31.4	39.4
101-120	41	10.1	24.4
121-150	41	10.1	73.2
151-180	15	3.7	133.3
181+	44	10.9	250.0
Unknown	122	30.1	-
Total Diabetic	405	100.0	76.5
Nondiabetic	45,658	100.0	22.1

SOURCE: Wheeler, FC. Unpublished 1980 data from the South Carolina Department of Health.

CHAPTER XXII. DIABETES AND CANCER

Marise S. Gottlieb, M.D., M.P.H.

SUMMARY

The incidence rates of diabetes and cancer have both been increasing for at least 30 years. However, whether there is a relationship between diabetes and cancer, particularly pancreatic cancer, continues to be an intriguing question. Despite many studies there appears to be no agreement. The most recent studies indicate no excess cancer deaths among persons with diabetes.

METHODOLOGIC PROBLEMS IN ASSESSING THE RELATIONSHIP BETWEEN DIABETES AND CANCER

The possibility that diabetes and cancer may share a common etiology derives from the observation that abnormalities of glucose metabolism frequently occur in patients with cancer of the pancreas and are often noted before the diagnosis of cancer is considered. This may be because extensive damage occurs to the islets from spread of the tumor within the pancreas, and perhaps to the liver from metastatic spread, before the primary diagnosis of pancreatic cancer is suspected. Moreover, the high frequency of noninsulin-dependent diabetes in adults, and the fact that older persons have the greatest frequency of cancer, increases the probability of observing abnormalities in glucose metabolism and cancer in the same patient. Therefore, the frequent coexistence of diabetes and cancer may occur as a result of their mutual metabolic impact in an aging population, not because of a common causal relationship between the diseases.

Studies using death certificates to assess the relationship between diabetes and cancer are suspect because of underreporting of diabetes as a diagnosis. In clinical studies on cancer patients, who are more likely to receive long-term medical care, there is a greater possibility that diabetes will be detected and recorded. Cross-sectional studies on nonrepresentative hospitalized patients are very likely to be biased and inaccurate in reporting disease associations, especially with regard to a causal relationship. Selective referral of hospitalized patients is likely because of the increased severity

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of their disease, and the real temporal relationship, if any, between the two conditions could be obscured.

Diabetes is often insidious in onset, while cancer of the pancreas, deep within the abdominal cavity, has often progressed extensively before producing symptoms that would prompt investigation and lead to a diagnosis. Because of their younger age at death, diabetics may not survive long enough for cancer to occur, and lower rates of cancer might be found. Therefore, groups of similar ages must be compared to assess the relationship between cancer and diabetes. To firmly establish the presence or absence of a relationship between the disorders, it would be necessary to assess the diabetic status in a population of about age 50 years and to follow them regularly with regard to their diabetic status and the number of cases of cancer that arise. The temporal relationship between cancer, particularly cancer of the pancreas, and diabetes could then be determined.

STUDIES ON CANCER IN PERSONS WITH DIABETES

Table 1 presents several studies on the occurrence of cancer in diabetic patients. There have been studies using either death certificates (Wilson and Maher 1932) or highly selected patient populations (Ellinger and Landsman 1944) that noted that diabetes and cancer occurred together more frequently than if the two diseases were completely independent. In contrast, several studies of the frequency of cancer in diabetic patients indicated a lower percentage than in the population as a whole, except for cancer of the pancreas (Herdan 1960, Kessler 1970). In autopsy studies, the overall frequency of cancer in diabetic persons did not appear to differ from that in nondiabetics, except that 1) carcinomas of the pancreas represented more of the cancers in diabetics compared to nondiabetics, and 2) more diabetic women (10.7 percent) were noted to have cancer of the endometrium compared to nondiabetic women (5 percent) (Warren et al. 1966). In a prospective study among diabetic persons in 1945-69, although an increased incidence of all cancer and of pancreatic cancer was noted, the increase disappeared after cases of diabetes occurring in the first year of observation were eliminated. These diabetes cases were probably due to the underlying malignancy (Ragozzino et al. 1982). These more recent studies also reflect an increasing sophistication in epidemiologic methods, and they do not support an etiologic relationship between cancer and diabetes.

The occurrence of an increased incidence of cancer of the pancreas among diabetics has been reported repeatedly (Kessler 1971). Among 44 Joslin Clinic patients with cancer of the pancreas, the mean duration of diabetes before death was 3.6 years and of cancer of the pancreas was 1.0 years; the average age at death was 62.2 years. In two studies of diabetic patients, cancer of the pancreas occurred in 13 percent and 12 percent. Although this is a much greater frequency than the 4.5 percent of deaths in the United States attributed to cancer of the pancreas, a selection factor can account for this observation. Diabetes associated with diagnosed cancer of the pancreas is very brittle; therefore, it is likely to be readily diagnosed and the patient referred for management. This factor would increase the number of pancreatic cancers found in this referral diabetic population. Although survival following diagnosis of cancer of the pancreas is less than 1 year, it may be due in part to the difficulty in detecting cancers in the abdominal cavity, since the pathologic process may well have begun much earlier and be far advanced before diagnosis can be made. Therefore, the 3.6-year duration of diabetes in these patients is more consistent with the duration of the malignant process than with the likelihood that the malignancy resulted from the diabetic state.

TABLE 1. *Studies reporting the occurrence of cancer and pancreatic cancer among patients with diabetes*

Reference	Year of Publication and Source	Number of Diabetics	Cases of Cancer		Cases of Pancreatic Cancer		Cancer of the Pancreas as a Percent of All Cancers in DMs
			Number	Percent	Number	Percent	
a	1928	2,179	37	1.7	12	0.6	33
b	1934 (Case records)	10,000	256	2.6	31	0.3	12
c	1941	182	38	20.9	6	3.3	16
d	1944 (1933-1941 case records)	1,280	39	3.1	2	1.6	5
e	1952	818	32	3.9	19	2.3	59
f	1957 (1911-1954 necropsies)	1,976	205	10.4	38	1.9	19
g	1959	1,026	67	6.5	8	0.9	12
h	1960 (Post-mortem records)	189	19	10.1	3	1.6	16
i	1961 (1955-1959 case records)	729					
		52 unstable			10	19.2	
		21 < age 60 years			10	48.0	
j	1970 (1898-1968 case records)	27,966	2,704	9.7			
k	1970 (1934-1959 case records)	21,447	902	4.2	78	0.36	9
			SMR = 0.95		SMR = 1.8		
l	1982 (1945-1969 population-based incidence cohort)	1,135	120	10.6	9	0.79	7.5
			R.R = 1.1 (1.0-1.3)		R.R = 4.3 (2.0-8.1)		
	Excluding first year of followup		101	8.9	5	0.44	5.0
			R.R = 1.1 (0.9-1.3)		R.R = 2.6 (0.9-6.1)		

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l. Ragozzino, MW et al. Subsequent cancer risk in the incidence cohort of Rochester, Minnesota residents with diabetes mellitus. J Chronic Dis 35:13, 1982.

Cancer of the pancreas is currently the fourth leading cause of death among deaths due to all cancers in the United States. Virtually no one survives this disease. It has been reported to occur more frequently in chemists and dry cleaners, and in persons whose occupations involve exposure to gasoline (Lin and Kessler 1981). It has also been weakly associated with cigarette smoking and variably related to alcohol consumption. More recently there have been reports of its association with drinking coffee: in one study a relationship with decaffeinated coffee was found (Lin and Kessler 1981), and a dose-related positive association with regular coffee consumption was found in another study (MacMahon et al. 1981). These do not reflect any specific relationship to diabetes.

Of all death certificates in 1978 in the United States reporting diabetes without mention of acidosis or coma, 0.94 percent also reported cancer of the pancreas. For diabetes with mention of acidosis or coma, 0.69 percent also listed pancreatic cancer (Table 2). The 55-to-64 year age group showed the most frequent occurrence of cancer of the pancreas for both types of diabetes: 1.15 percent for diabetes without mention of acidosis or coma (also for ages 65-74) and 1.59 percent for diabetes with mention of acidosis or coma.

In an autopsy series conducted from 1911-1954, carcinoma of the pancreas was found in 0.91 percent of all males (1.23 percent of those over 40 years of age) and 0.70 percent of all females (1.10 percent of those over 40 years of age) (Bell 1957). This is similar to the rate of pancreatic cancer in diabetics noted in Table 2.

TABLE 2. *Number of death certificates with diabetes listed either as underlying or secondary cause of death, and number and percent with cancer of the pancreas, United States, 1978*

	Age (Years)							
	All	0-34	35-44	45-54	55-64	65-74	75+	85+
Diabetes with mention of acidosis or coma (ICD 250.0)	5,214	312	250	452	820	1,301	1,423	652
With cancer of the pancreas	36	0	0	2	13	11	8	2
Percent of DM deaths	0.69	0	0	0.44	1.59	0.84	0.56	0.31
Diabetes without mention of acidosis or coma (ICD 250.9)	125,474	897	1,772	6,634	20,003	38,069	40,264	17,819
With cancer of the pancreas	1,185	0	5	42	230	440	370	99
Percent of DM deaths	0.94	0	0.28	0.63	1.15	1.16	0.92	0.56

SOURCE: 1978 United States multiple cause of death tables, unpublished data from the Division of Vital Statistics, National Center for Health Statistics.

In autopsy series of patients with both diabetes and cancer, there were too few of the usual pathological findings attributable to diabetes, such as renal arteriosclerosis, to confirm that diabetes had been present long enough to establish a causal relationship between the two diseases.

The reported increased frequency of occurrence of cancer of the endometrium and diabetes may possibly reflect another type of relationship linked to the high association of obesity with both conditions. However, one study suggested that diabetic women did not have an increased risk of death from cancer of the body of the uterus (Kessler 1970).

In a population-based study in Minnesota, no increased frequency of lymphoma among diabetic patients was found (Ragozzino et al. 1983).

STUDIES ON DIABETES IN CANCER PATIENTS

A number of studies have demonstrated a greater than expected occurrence of diabetes in patients with cancer and pancreatic cancer (Table 3), suggesting that the diagnosis of pancreatic cancer should be considered in a person with the onset of diabetes after age 60 years.

TABLE 3. *Studies reporting the occurrence of diabetes in cancer patients*

		All Cancers			Cancer of the Pancreas			Pancreatic Cancer as Percent of All Cancers in Diabetics
			With Diabetes			With Diabetes		
Reference	Year of Publication and Source	Number	Number	Percent	Number	Number	Percent	
a	1957 (1911-54 necropsies)				600	38	6.3	
b	1932 (Death certificates)	44,811	2,570	5.7	802	83	10.4	3.2 (83/2,570)
c	1960 (Post-mortem records)	1,212	19	1.6	3	3	100.0	15.7 (3/19)
	(Morbidity)	3,683	35	2.8				
d	1958 (1926-52 necropsies)							
	With DM before cancer					9	4.3	
	DM after cancer					32	15.3	
	Only glycosuria after cancer					61	29.2	
	Total				209	102	49.0	
e	1961 (1955-59 case records)				65	10	15.4	
	Diabetes diagnosed before malignancy and under age 60 years					9	14.0	
f	1969 (1955-67 case records)				265	51	19.3	
g	1981 (1972-75 case control)				94	8	8.5	

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APPENDIX A. *Number and percent of death certificates with diabetes (ICD250) as underlying cause of death which also mention a neoplasm, United States, 1978*

Type of Neoplasm (ICD Number)	Number Mentioned on Diabetes Death Certificates* Age 0-64	Number Mentioned on Diabetes Death Certificates* Age 65+	Percent of All Diabetes Death Certificates Age 0-64	Percent of All Diabetes Death Certificates Age 65+
All (140-239)	240	871	2.47	3.57
Large intestine, part unspecified (153.8)	12	87	0.12	0.36
Pancreas (157)	17	32	0.18	0.13
Bronchus and lung (162.1)	24	63	0.25	0.25
Breast (174)	20	109	0.21	0.45
Prostate (185)	6	121	0.06	0.50
Multiple neoplasms, site unspecified (199.0)	10	59	0.10	0.24

*Number of diabetes death certificates is 9,704 (age 0-64 years) and 24,374 (age 65 years and older).

SOURCE: M. Harris, National Diabetes Data Group, from multiple cause of death data filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

APPENDIX B. *Number and percent of death certificates with neoplasms (ICD 140-239) as underlying cause of death in which diabetes (ICD 250) is a contributing cause of death, United States, 1978*

Type of Neoplasm (ICD Number)	Number as Underlying Cause	With Mention of Diabetes	
		Number	Percent
All (140-239)	401,955	10,698	2.7
Large intestine, part unspecified (153.8)	33,937	920	2.7
Pancreas (157)	20,777	1,172	5.6
Bronchus and lung (162.1)	94,929	1,951	0.0
Breast (174)	34,609	860	2.5
Prostate (185)	21,674	597	2.8
Multiple neoplasms, site unspecified (199.0)	13,604	326	2.4

SOURCE: M. Harris, National Diabetes Data Group, from multiple cause of death data filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

CHAPTER XXIII. SELF-ASSESSED HEALTH STATUS OF ADULT DIABETICS

Thomas F. Drury, Ph.D., Pennifer A. Erickson, and Anita L. Powell

SUMMARY

About half of adult diabetics assess their health as fair or poor, while only about 16 percent of the general population 20 years of age and over describe their health in these unfavorable terms. At the favorable end of the health status spectrum, about 14 percent of adult diabetics assess their health as excellent, while as many as 44 percent of all adults rate their health that favorably.

INTRODUCTION

Adult diabetics have been found to have less favorable health status profiles than the general population (Krall et al. 1985). Even with age differences taken into account, levels of restricted activity days, bed-disability days, and work-loss days, as well as the prevalence of chronic activity limitation, are at least double for diabetics as compared to nondiabetics. Diabetics are at least twice as likely to report ever having had certain chronic diseases, and they are about twice as likely to visit physicians and to use short-stay hospitals. These morbidity, disability, and health service utilization differentials also translate into greater out-of-pocket health expenses for persons with diabetes. Persons whose lives are reflected in these findings bear a greater illness and health care burden than do persons whose lives are either unaffected or less affected by such concerns.

In recognition of this, increasing interest has developed in assessments of the effects of such burdens on various aspects of life quality (Erickson 1984a, b) and on how people cope with such burdens (Barish et al. 1983). This chapter on self-assessed health status is based on information obtained through the National Health Interview Survey (NHIS) of the National Center for Health Statistics (NCHS) (Bloom 1981). Survey participants were asked, "Compared to other persons your age, would you say that your health is excellent, good, fair, or poor?" Responses to this question have been found to be highly associated not only with specific morbidity, disability, health ser-

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vices utilization, and mortality, but also with other global assessments of well-being (Kaplan et al. 1983, LaRue et al. 1979, Ries 1983, Ware et al. 1978). Data from a similar query in the 1976-80 National Health and Nutrition Examination Survey (NHANES II) of NCHS are also included.

SELF-ASSESSED HEALTH STATUS

In 1979-81, while 44.4 percent of the general population 20 years of age and over assessed their health as excellent, only about 13.6 percent of similarly-aged diabetics rated their health that favorably (Figure 1, Appendix A). At the other end of the health status spectrum, about half (51.2 percent) of adult diabetics characterized their health as fair or poor. By contrast, only about 16.3 percent of the general population described their health in such unfavorable terms (see Appendix B).

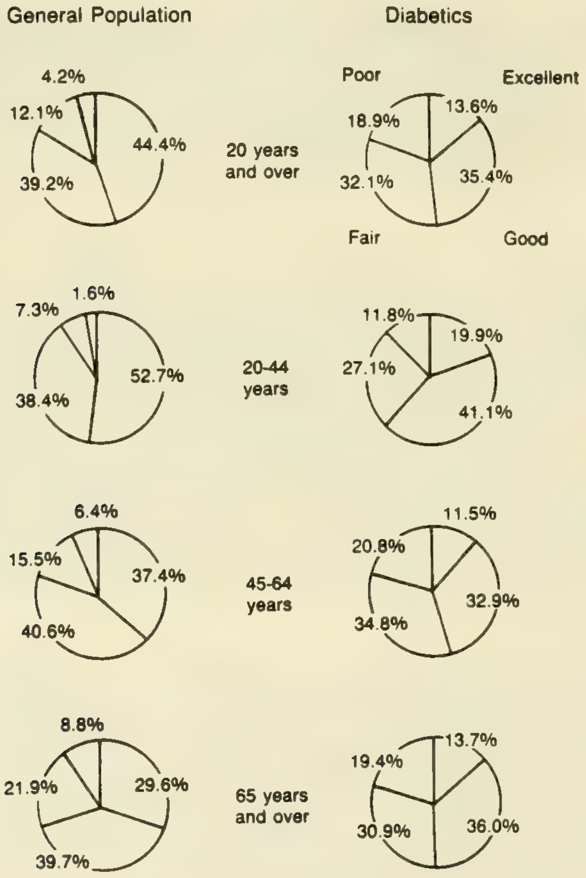

FIGURE 1. *Self-assessed health status of persons 20 years and over by diabetic status and age, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Since responses to questions about general health status may be subject to variation in question wording or answer categories, responses to two slightly different versions of self-assessed health status are compared in Table 1. There are slight differences between the two surveys in the percent of diabetics responding that their health was fair or poor. The percent of NHANES II respondents assessed as "excellent" or "good" are affected most, the "very good" appearing to have been recruited from their ranks.

TABLE 1. *Percent distribution of diabetics by self-assessed health status in two surveys, United States, 1976-81*

Self-Assessed Health Status	Age (Years)							
	20-74		20-44		45-64		65-74	
	NHANES*	NHIS**	NHANES	NHIS	NHANES	NHIS	NHANES	NHIS
Excellent	7.4	13.7	19.9	19.9	5.8	11.4	2.6	14.2
Very good	9.2	-	6.7	-	9.2	-	10.7	-
Good	29.6	34.3	41.5	40.9	27.3	32.9	26.4	32.9
Fair/poor	53.8	52.0	31.9	39.3	57.7	55.7	60.3	52.9
Fair	29.8	32.9	22.3	27.3	28.7	34.7	36.3	33.2
Poor	24.0	19.0	9.7	11.9	29.0	21.0	24.1	19.7

*NHANES II respondents were asked: "Would you say your health in general is excellent, good, fair, or poor?"; survey conducted in 1976-80; proxy responses were not permitted.

**NHIS respondents were asked: "Compared to other persons of your age, would you say your health is excellent, good, fair, or poor?"; survey conducted in 1979-81; proxy responses were permitted.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1976-80 NHANES II data provided by the Division of Health Examination Statistics and 1979-81 NHIS data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Some groups of diabetics are more likely to perceive themselves in fair or poor health than other groups are (Table 2). Among diabetics, those falling in the following categories were more likely to assess their health as fair or poor than other diabetics: persons 45 years and over, women, persons of other than white racial backgrounds, those with fewer years of schooling, persons in families with lower annual incomes, central city residents, persons living in nonfarm residences outside metropolitan areas, and residents of the South.

Combinations of some of these sociodemographic characteristics substantially increased the likelihood of fair or poor health assessments. Among persons 45-64 years of age, for example, about 81 percent of diabetics with less than a high school education who lived in poor families perceived their health as fair or poor (Table 3). This was about twice the proportion with such unfavorable health perceptions among similarly aged diabetics with a high school or more education in non-poor families. Among diabetics in their middle years, blacks with less than a high school education were about twice as likely to rate their health as fair or poor as whites with a high school or better education (Table 4). These white/black differentials in fair or poor health perceptions occurred in each major region of the country (Table 4).

TABLE 2. *Number and percent distribution of diabetics 20 years and over by self-assessed health status and selected characteristics, United States, 1979-81*

Characteristic	Number (Thousands)	Self-Assessment of Health			
		Excellent	Good	Fair	Poor
All persons 20 years and over with known diabetes	5,309	13.6	35.2	32.1	19.1
Age (years)					
20-44	806	19.9	40.9	27.3	11.9
45-64	2,396	11.4	32.9	34.7	21.0
65+	2,106	13.7	35.6	31.1	19.6
Sex					
Men	2,305	16.5	36.6	28.6	18.3
Women	3,004	11.4	34.1	34.8	19.7
Race					
White	4,402	14.3	37.3	30.7	17.7
All other races	907	10.0	25.1	39.1	25.8
Black	823	9.2	24.1	39.7	26.9
Education (years)					
<12	2,832	9.6	29.0	36.4	25.0
12	1,478	14.8	40.1	31.8	13.3
13 or more	924	24.1	47.4	19.4	9.2
Family income					
<$7,000	1,484	10.0	27.4	36.6	26.0
$7,000 - $9,999	570	10.0	33.5	34.5	22.0
$10,000 - $14,999	790	13.7	36.6	30.3	19.4
$15,000 - $24,999	893	16.9	40.3	30.8	12.0
$25,000 or more	987	19.9	47.2	25.2	7.7
Location of residence					
Within SMSA	3,528	15.1	36.3	31.4	17.2
Central city	1,658	13.0	33.5	33.4	20.0
Outside central city	1,870	16.9	38.8	29.7	14.7
Outside SMSA	1,782	10.7	32.9	33.5	22.8
Nonfarm	1,647	10.1	32.5	33.9	23.5
Farm	135	18.3	38.0	28.6	15.2
Geographic region					
Northeast	1,187	13.8	38.5	31.0	16.7
North Central	1,385	13.4	40.5	30.9	15.2
South	1,932	12.2	30.1	33.9	23.8
West	805	16.9	33.4	31.8	17.8

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

TABLE 3. *Percent of persons 45-64 years old who assess their health status as fair or poor, by income and education, United States, 1979-81*

Income and Education	General Population	Diabetics
Lower family income (<$7,000 annually)		
<12 years education	54.0	80.7
12+ years education	35.0	68.4
Higher family income (≥$7,000 annually)		
<12 years education	29.2	61.0
12+ years education	12.4	37.8

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

TABLE 4. *Percent of persons 45-64 years old reporting fair or poor health by race, education, and region, United States, 1979-81*

	General Population		Diabetics	
	White	Black	White	Black
Education				
<12 years	34.4	47.2	66.1	78.8
12+ years	13.5	26.5	39.9	60.8
Region				
Northeast	18.5	31.6	48.3	73.6
North Central	17.4	40.7	50.4	72.9
South	26.0	41.5	58.5	76.3
West	17.3	32.7	46.0	59.1

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

GLUCOSE TOLERANCE AND PERCEIVED HEALTH STATUS

With decline in glucose tolerance, from normal to overt diagnosed diabetes, a decreasing percent of persons ages 45-64 years characterized their health status as excellent or good; concomitantly, an increasing percent rated their health as fair or poor (Table 5).

CHRONIC CONDITIONS AND PERCEIVED HEALTH STATUS

Comparisons of diabetics to the more healthy general population may be inappropriate, and a more informative comparison might pair diabetics with persons in the general population who have other chronic diseases. When diabetics without a chronic condition shown in Table 6 are compared with persons in the general population without the same chronic condition, diabetics are at least twice as likely to assess their health as only fair or poor. However, when diabetics without a chronic condition are compared to persons in the general population with a chronic condition, the differences are markedly reduced. In some instances (e.g., heart trouble), the percentages are about the same. For arteriosclerosis, heart attacks, and stroke, diabetics without these conditions were somewhat less likely to assess their health as fair or poor than were persons in the general population with these conditions. When diabetics with a chronic condition were compared to the general population with that same condition, however, the differences in fair or poor health perceptions widened.

TABLE 5. *Percent distribution of persons 45-64 years old by self-assessed health status and glucose tolerance category, United States, 1976-80*

	Health Status**				
Glucose Tolerance Category*	Excellent	Very Good	Good	Fair	Poor
Normal glucose tolerance	19.0	27.2	33.4	13.7	6.7
Impaired glucose tolerance	13.0	22.4	34.5	20.9	9.3
Undiagnosed diabetes	10.4	18.8	29.4	33.1	8.3
Diagnosed diabetes	5.8	9.2	27.3	28.7	29.0

*National Diabetes Data Group criteria; 75-gram 2-hour OGTT.

**NHANES II respondents were asked, "Would you say your health in general is excellent, very good, good, fair, or poor?"

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

IMPAIRMENTS AND SELF-ASSESSED HEALTH STATUS

Similar findings were obtained when diabetics were compared with the general population in terms of fair or poor health assessments while taking into account whether or not the person had some impairment (Table 7). The highest levels of fair or poor health perceptions occurred among diabetics with a severe visual impairment, among whom 95.1 percent assessed their health in these unfavorable terms.

TABLE 6. *Age-adjusted* percent of persons 20 years and over who assess their health as fair or poor, by certain medical conditions, United States*

Chronic Condition	Both Sexes		Men		Women	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons 20 years and over	16.2	43.0	15.2	37.8	17.2	46.3
Ever had cataracts						
Yes	31.6	47.1	31.4	49.8	32.4	42.3
No	15.8	42.3	14.7	37.1	16.9	45.5
Ever had glaucoma						
Yes	31.8	62.2	25.5	60.5	38.3	63.4
No	16.1	42.6	15.1	37.3	17.1	45.9
Ever had arteriosclerosis						
Yes	53.6	75.9	52.0	53.8	55.7	89.6
No	15.4	41.2	14.3	36.0	16.4	44.6
Ever had hypertension						
Yes	29.9	57.7	26.6	49.0	32.9	61.2
No	13.5	35.0	13.1	32.1	14.0	37.3
Ever had heart attack						
Yes	52.5	69.9	48.5	69.8	58.7	69.4
No	15.3	41.1	14.1	35.2	16.4	44.9
Ever had other heart trouble						
Yes	41.2	72.5	39.2	70.4	42.9	73.6
No	14.7	39.5	13.8	34.1	15.6	42.9
Ever had stroke						
Yes	60.1	89.8	57.4	89.6	61.8	89.9
No	15.7	41.9	14.6	36.6	16.7	45.2
Ever had kidney trouble						
Yes	29.5	62.9	23.9	51.6	33.2	67.1
No	15.2	39.8	14.6	36.1	15.8	42.3
Ever had one or more of the above conditions						
Yes	28.3	55.4	26.0	48.4	30.4	58.5
No	11.2	29.3	10.6	26.1	11.8	32.0

*Age-adjusted by the direct method to the 1979-81 U.S. civilian noninstitutionalized population using 3 age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1976 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

TABLE 7. *Age-adjusted* percent of persons 20 years and over who assess their health as fair or poor, by certain impairments, United States*

	Both Sexes		Men		Women	
Impairment	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons 20 years and over	16.0	44.1	15.1	41.8	16.8	46.0
Visual impairment						
Yes	29.6	55.2	25.6	52.2	36.3	57.0
No	14.8	41.8	14.0	39.8	15.6	43.4
Severe visual impairment						
Yes	60.6	95.1	56.6	88.6	65.6	94.8
No	15.6	43.3	14.7	41.2	16.5	45.0
Other visual impairment						
Yes	27.3	52.2	23.6	49.5	33.7	53.6
No	15.2	42.9	14.4	40.6	16.0	44.7
Hearing impairment						
Yes	26.4	64.5	23.8	69.2	30.5	61.4
No	14.7	41.6	13.7	37.9	15.6	44.3
Speech impairment						
Yes	43.0	60.2	40.6	50.0	47.5	90.7
No	15.8	44.0	14.8	41.7	16.7	45.8
Paralysis, complete or partial						
Yes	46.6	74.8	43.3	90.2	50.3	63.8
No	15.7	43.6	14.7	41.0	16.6	45.7
Absence of major extremities						
Yes	38.0	26.3	43.6	31.4	20.6	41.6
No	15.9	44.1	15.0	41.6	16.8	46.0
Absence of entire finger(s) or toe(s)						
Yes	23.2	48.4	21.7	46.0	30.1	75.9
No	15.9	44.0	14.9	41.6	16.8	45.9
One or more orthopedic impairments except paralysis or absence						
Yes	29.1	54.0	27.3	55.7	31.2	52.9
No	14.2	42.3	13.3	39.2	15.0	44.6
Back or spine						
Yes	29.3	55.4	27.9	59.0	30.8	53.2
No	15.1	43.2	14.3	40.5	15.9	45.3
Upper extremity and shoulder						
Yes	27.5	47.8	26.1	40.7	29.6	60.0
No	15.8	44.0	14.8	41.8	16.7	45.7
Lower extremity and hip						
Yes	29.4	50.2	27.6	53.7	32.2	46.3
No	15.4	43.7	14.5	41.1	16.3	45.7
Other and multiple limbs, back and trunk						
Yes	40.5	69.5	38.4	89.2	42.9	58.9
No	15.8	43.9	14.8	41.3	16.7	45.8
Other impairment, not elsewhere classified						
Yes	37.5	63.5	39.2	67.4	37.4	60.0
No	15.6	43.5	14.7	41.1	16.4	45.5
One or more of the above impairments						
Yes	26.6	53.6	24.0	52.0	30.1	55.2
No	11.6	37.7	10.6	33.2	12.5	40.8

*Age-adjusted by the direct method to the 1979-81 U.S. civilian noninstitutionalized population using 3 age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

LIMITATION OF ACTIVITY AND SELF-ASSESSED HEALTH STATUS

Persons with limitation of activity due to chronic conditions or impairments are more likely to assess their health as fair or poor than are persons without such limitations, and the more severe the limitation, the greater the likelihood of perceiving one's health in unfavorable terms. What is true generally is also true for diabetics, only more so (Table 8). Moreover, diabetics who reported diabetes as the cause of their activity limitation were more likely to describe their health as fair or poor than diabetics limited for other reasons (Table 9). Among younger diabetics, fair or poor health perceptions were more prevalent among those who are limited for reasons other than diabetes; among older diabetics, these perceptions are less common among diabetics limited due to other reasons.

TABLE 8. *Age-adjusted* percent of persons 20 years of age and over who assess their health as fair or poor, by certain limitation of activity categories, United States, 1979-81*

Limitation Category	General Population	Diabetics
Not limited	7.9	26.7
Limited	-	70.2
Unable to perform usual activity	72.2	81.8
Limited in amount or kind of usual activity	50.3	69.5
Limited in other than usual activity	27.3	46.2
Limited due to diabetes	-	73.6
Limited but not due to diabetes	-	66.0

*Age-adjusted by the direct method to the 1979-81 U.S. civilian noninstitutionalized population using 3 age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

TABLE 9. *Percent of diabetics 20 years of age and over who assess their health as fair or poor, by certain limitation of activity categories, United States, 1979-81*

	Limited Due To:			
Age (Years)	All Causes	Diabetes	All Except Diabetes	Not Limited
20+	70.2	73.8	66.0	26.7
20-44	65.5	62.4	72.3	24.6
45-64	77.2	79.1	74.7	29.3
65+	64.5	71.2	58.2	24.4

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

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APPENDIX A. *Percent of persons 20 years and over who report they are in excellent health, by diabetic status, age, and selected characteristics, United States, 1979-81*

	Age (Years)							
	20+		20-44		45-64		65+	
Characteristic	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons 20+ years	44.4	13.6	52.6	19.9	37.2	11.4	29.4	13.7
Sex								
Men	48.3	16.5	56.9	22.1	40.6	14.8	30.1	16.6
Women	40.9	11.4	48.6	18.3	34.2	8.3	28.9	11.9
Race								
White	45.9	14.3	54.6	21.9	38.6	11.9	30.4	14.2
All other races	33.3	10.0	40.0	11.8	24.5	9.0	18.7	10.6
Black	31.7	9.2	38.6	9.2	22.8	8.8	17.5	10.0
Education (years)								
<12	26.9	9.6	35.1	9.6	22.6	8.4	22.9	10.6
12	45.4	14.8	50.8	18.5	38.6	13.1	33.4	15.8
13 or more	59.4	24.1	62.6	30.9	55.1	17.8	46.4	26.3
Family income								
<$7,000	29.0	10.0	39.2	8.6	17.9	7.6	23.8	11.7
$7,000-$9,999	34.9	10.0	45.0	14.5	24.6	10.1	27.6	9.1
$10,000-$14,999	41.3	13.7	48.4	13.2	31.1	11.5	32.3	16.7
$15,000-$24,999	48.7	16.9	55.0	20.3	38.1	14.2	36.2	19.0
$25,000 or more	56.2	19.8	61.5	31.8	49.6	13.6	42.2	21.9
Location of residence								
Within SMSA	45.8	15.1	53.2	20.6	39.6	12.5	30.6	15.9
Central city	41.7	13.0	48.7	18.5	36.3	11.2	28.3	13.0
Outside central city	48.6	16.9	56.1	22.3	41.9	13.7	32.6	18.4
Outside SMSA	41.3	10.7	51.4	18.3	32.0	8.8	27.0	10.1
Nonfarm	41.3	10.1	51.3	18.0	31.8	7.9	27.0	9.5
Farm	41.0	18.3	53.2	26.9	34.2	19.1	27.4	16.5
Geographic region								
Northeast	44.9	13.8	55.4	21.0	36.5	11.4	27.8	14.0
North Central	44.1	13.4	52.2	21.2	37.5	10.8	28.3	13.2
South	41.6	12.2	49.7	15.5	34.0	9.5	28.4	14.3
West	48.8	16.9	55.0	24.6	43.6	17.5	34.8	13.0

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX B. *Percent of persons 20 years and over who report they are in fair or poor health, by diabetic status, age and selected characteristics, United States, 1979-81*

	Age (Years)							
	20+		20-44		45-64		65+	
Characteristic	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons 20+ years	16.3	51.2	8.9	39.3	22.0	55.7	31.0	50.7
Sex								
Men	15.0	46.9	7.5	34.5	21.5	50.2	31.4	47.3
Women	17.5	54.5	10.3	42.5	22.5	60.8	30.7	52.9
Race								
White	15.2	48.4	8.0	35.5	20.3	52.3	29.2	48.8
All other races	24.9	64.9	15.3	54.3	36.4	70.0	48.1	62.6
Black	26.5	66.7	16.2	56.6	38.7	73.2	49.4	62.5
Education (years)								
<12	31.4	61.4	19.5	54.4	36.4	68.9	38.6	56.3
12	12.6	45.1	8.5	36.5	17.3	48.7	23.3	44.1
13 or more	6.7	28.5	4.6	27.6	9.8	28.8	14.9	28.9
Family income								
<$7,000	31.6	62.6	18.3	59.6	47.7	77.7	37.1	53.8
$7,000-$9,999	24.7	56.5	13.1	44.7	35.0	66.7	34.6	50.8
$10,000-$14,999	16.5	49.7	9.4	31.9	25.2	58.0	27.4	44.5
$15,000-$24,999	11.5	42.8	7.1	37.0	17.9	43.5	23.9	46.8
$25,000 or more	7.7	33.0	5.1	26.8	10.4	33.4	17.8	38.1
Location of residence								
Within SMSA	14.9	48.6	8.6	36.3	19.6	53.9	29.3	47.2
Central city	17.7	53.4	10.5	45.9	23.0	59.0	31.4	49.4
Outside central city	13.1	44.3	7.4	28.1	17.3	49.2	27.5	45.3
Outside SMSA	19.4	56.4	9.7	46.0	27.3	59.8	34.1	56.5
Nonfarm	19.4	57.4	9.7	46.5	27.9	61.5	34.3	57.2
Farm	19.1	43.8	9.7	28.7	23.0	40.6	32.2	48.3
Geographic region								
Northeast	14.7	47.7	7.6	35.8	19.6	52.4	27.6	46.6
North Central	14.5	46.1	8.1	28.7	18.9	53.1	28.7	45.2
South	20.2	57.7	10.7	45.2	28.4	62.2	37.2	56.8
West	14.1	49.7	8.6	48.9	18.3	48.3	27.3	51.4

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

CHAPTER XXIV. THERAPY FOR DIABETES

Donald B. Martin, M.D., and Andrew R. Quint, M.D.

SUMMARY

In the United States, about 25 percent of diabetics use insulin and 35 percent use oral hypoglycemic medications. Three-fourths of these also use a diet for control of their diabetes, while 15 percent of diabetics use a diet alone. About 25 percent of diabetics are not on any of these three therapies. The proportion of diabetics using insulin decreases with increasing age, while the proportion using oral agents increases. Use of diet therapy is approximately constant across age groups. There is little or no difference in therapy by race or sex. About 40 percent of diabetics test their urine for glucose daily. The frequency of blood glucose tests is not well documented, but may average fewer than four times per year per diabetic. Home blood glucose monitoring has become widely accepted. There has been only one study on the subject. It suggests that only about 5 percent of patients with noninsulin-dependent diabetes mellitus (NIDDM) and 30 percent of patients with insulin-dependent diabetes mellitus (IDDM) practice home blood glucose monitoring.

INTRODUCTION

Therapy for diabetes has certain special broad aspects, and a long-range goal for care of persons with this disease needs to be established for each individual patient. Grafted onto this are interval decisions regarding diet, hypoglycemic therapy, monitoring of metabolic status and assessment, treatment, and prevention of the complications of diabetes.

There are several goals for any patient with diabetes: (1) There must be appropriate interaction between patients and health care professionals. Both adequate time and an appropriate place should be arranged so that patients can have questions answered in detail to permit ongoing patient education. Inadequate interaction between health care professionals and patients is a major cause of failure of the most carefully laid out therapeutic program. (2) An appropriate diet should be instituted. In children with IDDM, this should provide sufficient calories to allow normal growth and

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development. In obese patients with NIDDM, a weight reduction program should be emphasized, and in such patients, weight loss alone may obviate the need for further pharmacologic therapy. Diet should be appropriate for patients in terms of their ethnic background and socioeconomic status. (3) Symptoms of hyperglycemia should be controlled. Even physicians who are not enthusiastic about "tight control" acknowledge that it is critical to control hyperglycemic symptoms. (4) Hypoglycemic symptoms should be avoided. Even the strongest proponents of "tight control" acknowledge that repeated episodes of symptomatic hypoglycemia are uncalled for, are disabling for the patient, and make any therapeutic program essentially impossible to achieve. (5) Normalization or near normalization of blood glucose is a desirable therapeutic goal. While there are arguments as to the pros and cons of "tight control," most physicians acknowledge that there may be a relationship between level of blood glucose and the ultimate development of complications of diabetes. This relationship justifies attempts to regulate blood glucose to levels as near physiological as possible.

THERAPEUTIC PROGRAMS IN CURRENT USE

It is difficult to get accurate data on the use of various therapeutic modalities for treatment of diabetes. Hospital records or diabetes center records tend to provide biased data. Another approach has been to derive this information from interview surveys. Table 1, from a 1976-80 national household survey, displays the percent of patients with diabetes using various therapeutic modalities. As can be seen, a sizable number of patients (24 percent) are under no specific program. The percent of patients on insulin seems somewhat high in relation to the low frequency of IDDM and probably indicates the use of insulin by patients with NIDDM to control their blood glucose. A similar phenomenon was seen in the outpatient population of Public Health

TABLE 1. *Percent of diagnosed diabetics by current and previous diabetes therapies and age, United States, 1976-80*

	Age (Years)					
Therapy	12-74	12-34	35-44	45-54	55-64	65-74
Currently using insulin	27	46	47	22	21	24
Used insulin for most of the past year	26	46	47	22	19	23
Ever used insulin	36	51	49	35	27	35
Currently using diabetes pills	35	7	15	34	39	47
Used pills for most of the past year	34	7	11	31	41	46
Ever used diabetes pills	65	35	51	60	73	75
Currently using a written diet	48	35	46	48	53	48
Using diet only	14	6	9	16	19	12
Using insulin and written diet	18	22	32	17	15	16
Using pills and written diet	16	7	4	15	19	20
Ever given a written diet	75	77	74	72	79	73
Not currently using insulin/pills/diet	24	41	29	28	21	17
Ever used insulin	2	4	0	6	1	1
Ever used diabetes pills	8	7	8	7	10	8

SOURCE: Harris, MI, National Diabetes Data Group, from data on 756 persons who reported a physician's diagnosis of diabetes in the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

Service clinics in 1978-79 and in earlier national interview surveys (Table 2). The patterns of past and current use of diabetes therapies by age at diagnosis seems to corroborate this, in that a larger proportion of young-onset diabetics are using insulin (Table 3). The same downward trend with increasing age in the proportion using

TABLE 2. *Percent of diabetics using insulin, oral hypoglycemic agents, and diet therapy, 1964-79*

Population, Date, Age (Years)	Insulin	Oral Agents	Diet Only
United States, 1964-65[a]			
Age 25-44	30	31	-
45-54	25	49	-
55-64	21	56	-
65-74	23	53	-
75+	21	55	-
All ages	26	48	-
United States, 1976[a]			
Age 20-39	31	15	27
40-59	23	36	20
60+	18	50	17
All ages	22	40	19
U.S. Public Health Service Outpatient Clinics, 1978-79[b]			
Age <30	51	11	-
31-40	36	20	-
41-50	23	28	-
51-60	25	39	-
61-70	21	44	-
>70	22	47	-

TABLE REFERENCES

a. Drury, TF, and MI Harris, National Diabetes Data Group, from data of the National Health Interview Surveys, National Center for Health Statistics.
b. Rendell, M, et al. A pharmaceutical profile of diabetic patients. J Chronic Dis 36:193-202, 1983.

TABLE 3. *Percent of diabetics by age at diagnosis and current treatment regimen, United States, 1976-80*

	Age at Diagnosis (Years)					
	0-74	0-29	30-49	50-59	60-69	70-74
Percent currently using:						
Insulin	27	52	31	18	16	19
Oral hypoglycemic agents	35	6	31	47	44	43
Written diet	48	43	49	48	51	49
Written diet only	14	7	14	16	17	12
None of the above	24	35	24	18	23	26
Total	100	100	100	100	100	100

SOURCE: Harris, MI, National Diabetes Data Group, from data on 756 persons who reported a physician's diagnosis of diabetes in the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

insulin is also seen in a population-based study of diabetics in southern Wisconsin diagnosed at age 30 years or older, which probably includes few patients with IDDM (Table 4). Thus there appears to be a number of older patients who are using insulin with or without a prescribed diet for their care. There are also a number of younger patients using oral medication for treatment of diabetes.

Insulin was more frequently prescribed as the duration of diabetes increased, and the proportion of diabetics on neither insulin nor oral hypoglycemic agents declined with increasing duration of diabetes (Tables 5 and 6). The percent using oral agents showed no clear relationship to duration of diabetes. Young diabetics currently being treated with insulin have used it for the duration of their diabetes, but older diabetics using insulin have a history of use of oral agents also (Table 7). Both groups have complemented these drug therapies with diet for most of the duration of their disease. Current users of oral agents have virtually never been treated with insulin, and persons currently using diet alone have little experience with either insulin or oral hypoglycemic drugs. Persons with no current therapy have short histories of use of insulin, orals, or diet (Table 7).

TABLE 4. *Percent of diabetics by age at diagnosis and current treatment regimen, southern Wisconsin, 1979-81*

	Age at Diagnosis (Years)					
	30-39	40-49	50-59	60-69	70-79	80+
Number of diabetics*	550	1,166	1,704	1,645	840	169
Percent currently using:						
Insulin	67	48	38	28	22	19
Oral hypoglycemic agents	18	33	38	45	51	51
Neither	15	19	24	27	30	30

*Random serum glucose >200 mg/dl or fasting serum glucose >140 mg/dl on two occasions.

SOURCE: Klein, R, et al. Hypoglycemic therapy in patients diagnosed to have diabetes at 30 years of age or older. J Chronic Dis 37:159-65, 1984.

TABLE 5. *Percent of diabetics age 12-74 years by duration of diabetes and current treatment regimen, United States, 1976-80*

	Duration of Diabetes (Years)				
	All	0-4	5-9	10-14	15+
Percent currently using:					
Insulin	27	19	22	31	51
Oral hypoglycemic agents	35	35	36	38	27
Written diet	48	47	46	51	51
Written diet only	14	17	15	12	7
None of the above	24	29	26	19	16
Total	100	100	100	100	100

SOURCE: Harris, MI, National Diabetes Data Group, from data on 756 persons who reported a physician's diagnosis of diabetes in the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

TABLE 6. *Percent of diabetic patients age 30+ years at diagnosis, by duration of diabetes and treatment regimen, southern Wisconsin, 1979-80*

	Duration of Diabetes (Years)			
	0-4	5-9	10-14	15+
Number of diabetics	2,582	1,823	925	744
Percent currently using:				
Insulin	25	34	50	68
Oral hypoglycemic agents	39	44	40	27
Neither	36	28	10	5

SOURCE: Klein, R, et al. Hypoglycemic therapy in patients diagnosed to have diabetes at 30 years of age or older. J Chronic Dis 37:159-65, 1984.

TABLE 7. *Mean years duration of diabetes and diabetes therapies, by current age and therapy, United States, 1976-80*

	Current Age (Years)				
	20-74	20-34	35-54	55-64	65-74
All diabetics* (100%)					
Diabetes	8.0	8.1	7.0	7.2	9.9
Insulin	2.2	4.3	2.5	1.4	2.2
Orals	3.1	0.5	1.8	3.5	4.9
Diet	4.4	4.1	4.0	4.5	5.0
Current insulin users (26%)					
Diabetes	11.3	10.8	9.9	11.1	13.3
Insulin	8.1	10.6	8.2	6.4	8.1
Orals	2.8	0.2	1.8	3.8	4.4
Diet	8.3	7.9	8.3	8.2	8.7
Current orals users (35%)					
Diabetes	7.5	3.4	4.8	6.6	10.2
Insulin	0.1	0.0	0.0	0.0	0.3
Orals	5.4	2.2	3.6	5.3	6.8
Diet	3.4	3.0	2.0	3.7	4.2
Current diet only users (14%)					
Diabetes	6.1	4.4	6.9	5.6	6.1
Insulin	0.1	0.0	0.0	0.0	0.1
Orals	1.4	0.8	0.2	2.1	1.8
Diet	4.9	4.2	4.0	5.3	5.4
Currently no therapy (24%)					
Diabetes	6.4	7.2	6.1	6.0	7.1
Insulin	0.2	0.2	0.3	0.1	0.3
Orals	1.1	0.4	0.8	0.9	2.4
Diet	1.4	1.0	1.4	1.5	1.6

*Mean duration of diabetes and therapies averaged over all diabetics.

SOURCE: Harris, MI, National Diabetes Data Group, from data on 756 persons who reported a physician's diagnosis of diabetes in the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

The use of diabetes therapies varies little by race or sex (Table 8). The use of oral hypoglycemic agents declines with increasing family income, but proportions of diabetics on insulin or diet therapy are the same across family income levels.

TABLE 8. *Percent of diabetics by diabetes therapy during the past year by race, sex, and family income, United States, 1976*

	Males		Females		Family Income		
Therapy	White	Nonwhite	White	Nonwhite	<$10,000	$10-15,000	>$15,000
Insulin	24	30	18	22	21	22	24
Diabetes pills	40	45	42	46	46	38	32
Diet	49	45	57	55	55	55	50
None of the above	20	22	18	19	18	21	22

SOURCE: Drury, TF, and MI Harris, National Diabetes Data Group, from data on 2,442 persons who reported a physician's diagnosis of diabetes in the 1976 National Health Interview Survey, National Center for Health Statistics.

TIME TRENDS IN DIABETES THERAPY

There have been only slight changes in the proportion of diabetics using various therapies during 1960-81, despite the fact that during this period the diabetic population almost tripled (Table 9).

DIET

Diet is the cornerstone of therapy of all patients with diabetes and must be tailored in terms of calorie need, social and ethnic background, and lifestyle (ADA 1979, Arky et al. 1982). Several aspects of the diabetic diet have been recognized as essential; several other aspects are of interest and may play a role as the long-term effects of dietary manipulation are better understood. Absolutely paramount in importance is the number of calories. Calories must be adjusted to allow overweight NIDDM patients to lose weight; in contrast, children with IDDM must be allowed the proper number of calories to grow and develop normally. The need for additional pharmacologic therapy—insulin or oral hypoglycemic agents—can be most fairly assessed in the setting of a constant, appropriate level of caloric intake. The distribution of calories throughout the 24-hour period is important for patients taking a pharmacologic agent for treatment of hyperglycemia, with special emphasis for patients who are on insulin therapy.

Of less importance than the total number of calories is the percent of carbohydrate in the diet of diabetic patients. In the past, diabetics were often taught a diet that was relatively low in the amount of carbohydrate, in the 35-40 percent range. It has become appreciated that the amount of carbohydrate in the diet, as long as the total number of calories remains the same, has relatively little impact on blood and urine glucose levels. For example, modifying the diet from 40 percent to 60 percent carbohydrate while keeping total calories constant has little effect on the usual parameters measured (Weinsier et al. 1974). There has been some concern that a diet high in carbohydrate might adversely affect blood triglycerides and perhaps cholesterol in the

TABLE 9. *Number of diabetics in the United States and percent using various diabetes therapies, 1960-81*

	1960-62 (a)	1964-65 (b)	1970 (c)	1976 (d)	1976-80 (d)	1978-79 (e)	1980 (f)	1979-81 (g)
Millions of diabetics	1.9	2.3	-	5.0	5.2	5.1	5.5	5.4
Percent using:								
Insulin	33	28	24	22	26	26	26	37
Oral agents	43	48	24	40	35	35	27	40
Diet	-	-	-	53	48	-	51	-
Diet only	-	-	52	19	14	-	16	-
None of the above	-	-	0	19	25	-	32	-

TABLE REFERENCES AND NOTES

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b. Bauer, ML. Characteristics of persons with diabetes. National Center for Health Statistics, Vital and Health Statistics Series 10, No. 40, October 1967; national sample survey.
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e. Rendell, M, et al. A pharmaceutical profile of diabetic patients. J Chronic Dis 36:193-202, 1983; outpatient population of United States Public Health Service Clinics.
f. Halpern, M, DL Dodson, J Beasley. Diabetes in Michigan, 1980. Michigan Department of Health, Lansing, MI, September 1983; based on responses of 189 diabetics in a household survey of 3,073 persons.
g. Klein, R, et al. Hypoglycemic therapy in patients diagnosed to have diabetes at 30 years of age or older. J Chronic Dis 37:159-65, 1984; southern Wisconsin study data include only diabetics with age at onset >30 years; mean current age = 65 years.

long term. This has not yet been seen. Of epidemiologic interest is that the diet of diabetic patients in the Orient has always been high in carbohydrate, and those Orientals who moved to Hawaii, where their diet contained more fat, were found to have increased risk of cardiovascular events. The type of carbohydrate and the effect of various relatively simple carbohydrates on blood glucose fluctuations are the subject of intense research, but initial observations seem to suggest they are less important than was once thought (Bantle et al. 1983). Another aspect of diet is the percent of unsaturated fat in relation to total fat intake. While trials of primary prevention of cardiovascular disease are few, they indicate that this is affected by dietary unsaturated fat intake (Turpeinen et al. 1968). For this reason, many health care professionals emphasize this aspect of diet in treatment of patients with diabetes. There has been some concern that these diets may lead to increased incidence of cancer, but this has not been widely accepted (Dayton et al. 1969).

Another aspect of diet that has received considerable attention is the effect of fiber on glucose control (Anderson et al. 1979, Jenkins et al. 1977). It appears that addition of fiber to diabetic diets leads to less intense postprandial hyperglycemia. Most health care professionals are interested in providing adequate fiber for their patients, expecting it to be beneficial not only for bowel health but also for hyperglycemia. Unfortunately, the currently available forms of fiber for patient use are not attractive and are only reasonably palatable.

The major problem in dealing with patients with diabetes with regard to their diets is the lack of efficacy of instruction and patient compliance. Physicians and other health care professionals who deal with this problem recognize that the majority of patients do not follow a prescribed diet, and this is especially true for overweight NIDDM patients. For example, one-third of diabetics surveyed in 1977 indicated that they snack between or after meals every day (Drury 1977). Even more upsetting are the observations that dietary instruction has not been seriously offered to patients. In only 37 percent of visits for diabetes to physicians in 1977 was diet counseling offered (Ezzati 1980). While three-fourths of diabetics in 1976-80 reported that they had been given a written diet for their diabetes, only about half were using a diet, either alone or in conjunction with insulin or oral agents (Table 1). Similar proportions occurred in the 1976 national survey (Table 2). The proportions given and using a diet did not differ by current age (Table 1). The proportion of diabetics using a diet also did not differ by age at diagnosis of diabetes (Table 3) or duration of diabetes (Table 5), except that the percent using a written diet only did decline with increasing duration (Table 5). Current insulin and diet only users had a longer history of diet therapy relative to their duration of diabetes than current users of oral hypoglycemic medications (Table 7).

There is great interest in using newer techniques to produce and maintain weight loss in NIDDM patients. However, a representative study comparing behavior modification, nutrition education, and a control group demonstrated three aspects of a recurrent theme: all techniques can be successful in the short term, the amount of weight loss is modest, and long-term (here 16 months) effects are not maintained (Figure 1).

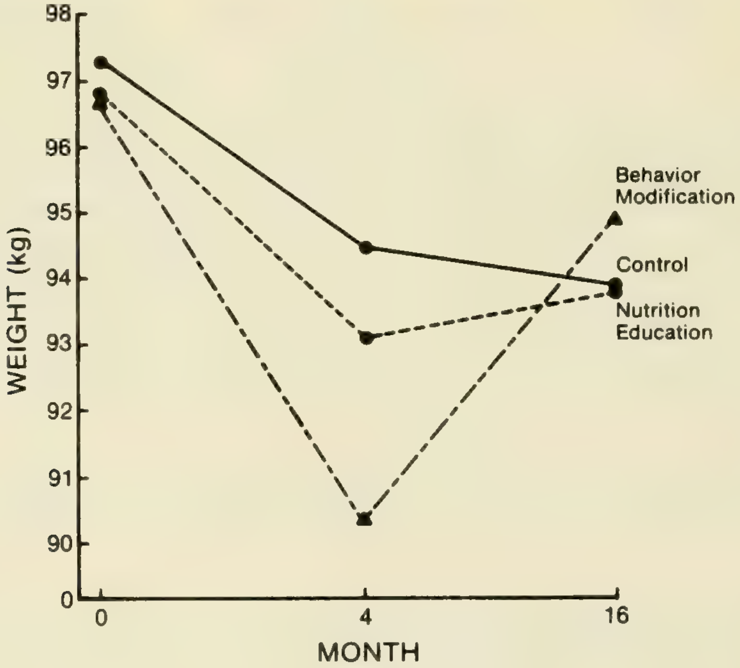

FIGURE 1. *Effect of education on weight loss*

SOURCE: Wing, RR, et al. University of Pittsburgh. Unpublished data, 1984.

ORAL AGENTS

In the evaluation and initiation of therapy in patients with NIDDM, the physician must decide when to start pharmacologic treatment. While diet is the first and most important arm of therapy, there are occasions when the patient's blood glucose and metabolic status dictate early and immediate treatment. One therapeutic modality available for treatment of NIDDM is the use of oral agents, limited in this country to oral sulfonylurea medication. These drugs have been in use here for approximately 30 years. Prescription data since 1976 are presented in Table 10. The proportion of diabetics using oral agents declined slightly in 1960-81, while the number of diagnosed diabetics increased 2.8-fold (Table 9). In 1984, the FDA approved two new oral sulfonylurea agents for treatment of diabetes, glipizide and glyburide. These two medications are much more potent than the earlier sulfonylureas. The mechanism by which they produce long-term lowering of blood glucose is not completely clear; acutely, these drugs stimulate pancreatic secretion of insulin, although chronically, a potentiation of peripheral insulin action and/or hepatic effects may be more important (Simonson et al. 1984). It is important to recognize that patients for whom these medications are prescribed must be carefully selected. No patient with IDDM is a candidate for this therapy. These drugs are not usually effective during periods of stress (for example, surgery) or pregnancy. It should also be emphasized that these medications are not to be dispensed in lieu of a proper diet but are only to be used as a supplement to diet therapy.

Although 65 percent of diabetics had used oral agents for their diabetes in the past, only 35 percent were using them when surveyed in 1976-80; about half of current users complemented this therapy by following a written diet for their diabetes (Table 1). The proportion using oral hypoglycemic medications increased with age of the diabetic (Tables 1 and 2) and with age at diagnosis (Tables 3 and 4), but showed no relationship to duration of diabetes except for a smaller rate in those with diabetes for 15 or more years (Tables 5 and 6). Current orals users have little or no history of insulin use, but have used diet as a therapy for about half of the duration of their diabetes; current insulin users over age 34 appear to have been placed on oral hypoglycemic medication

TABLE 10. *Dispensed pharmacy retail prescriptions of oral hypoglycemics (in millions), United States, 1976-83*

	1976	1977	1978	1979	1980	1981*	1982	1983
Millions of diabetics	5.0	-	5.2	5.1	5.5	5.6	-	-
Acetohexamide	1.4	1.3	1.2	1.0	0.9	0.9	0.9	0.8
Chlorpropamide	6.2	6.4	6.4	6.1	6.8	8.1	8.8	8.8
Tolazamide	2.0	2.1	2.3	2.3	2.7	3.0	3.6	4.2
Tolbutamide	4.7	4.5	4.1	3.6	3.1	3.3	3.3	3.2
Phenformin	3.5	2.1	-	-	-	-	-	-
Total	17.8	16.4	14.0	13.0	13.5	15.3	16.6	17.0

*In 1981 the NPA methodology was changed such that data before 1981 may not be comparable to data in 1981-83, and any differences may be an artifact of that change.

SOURCE: United States Food and Drug Administration, from data of the National Prescription Audit, IMS America, Ambler, PA.

for the first third of their diabetes before being switched to insulin (Table 7). There were few differences between males and females or between whites and nonwhites in the proportion using oral hypoglycemic agents, although the proportion decreased with increasing family income (Table 8).

For about 15 years there has been controversy about the clinical use and safety of oral agents, stemming from the University Group Diabetes Program (UGDP 1970) multicenter oral agent trial. There were two important issues raised by this study. The first relates to the reported increase in cardiovascular mortality with the use of one of these agents (tolbutamide); this controversy will never be formally resolved, and physicians treating diabetics must decide the importance of these data. No national data have been analyzed on physicians' habits of prescribing insulin or oral hypoglycemic agents for diabetes. However, in a population of 6,074 diabetics in southern Wisconsin in 1979-80, patients of internists were less frequently treated with oral hypoglycemic agents than were patients of general practitioners (Table 11). In the United States in 1980, about 33 percent of office visits for diabetes to physicians were made to internists and 48 percent were to general and family practitioners (Harris 1980). The other issue is the importance of diet. The study showed that diet was about as effective as oral agents over time and achieved roughly the same blood glucose levels (AMA 1980). These observations not only stress the need for an appropriate diet, but point out the need on the part of the physician for ongoing testing of the effectiveness of these medications. So-called secondary pharmacologic failures can occur. This is further complicated by the need for constant reinforcement of a dietary program which, if not followed, can counteract the pharmacologic effect of these agents.

TABLE 11. *Percent of diabetic patients by physician specialty and treatment regimen, southern Wisconsin, 1979-80*

	Internist	General Practitioner
Number of diabetic patients	3,121	2,130
Mean age of patient (years)	64.9	65.3
Mean age at diagnosis (years)	56.9	58.0
Percent using:		
Insulin	39	33
Oral hypoglycemics	35	47

SOURCE: Klein, R, et al. Hypoglycemic therapy in patients diagnosed to have diabetes at 30 years of age or older. J Chronic Dis 37:159-65, 1984.

INSULIN THERAPY

Therapy with insulin is the mainstay of pharmacologic treatment of patients with IDDM, and all diabetics with IDDM are, by definition, treated with insulin (NDDG 1979). It is also commonly used in patients with NIDDM who are unable to maintain appropriate blood glucose levels with diet therapy, with or without the addition of a sulfonylurea.

About one-fourth of diabetics were using insulin and had used insulin for most of the previous year when surveyed in 1976-80, although one-third had used insulin at some time during their diabetes (Table 1). About two-thirds of those currently on insulin were also employing a diet for therapy of their diabetes. The proportion on insulin at ages 45-74 years was about half that of younger ages, but a substantial number of older diabetics, presumably NIDDM, were being treated with insulin. There was a distinct decline in insulin use with increasing age at diagnosis that was greater than the decline seen with increasing current age (Tables 3 and 4). Conversely to the pattern with oral hypoglycemic agents, the proportion of diabetics using insulin increased with increasing duration of diabetes (Table 6), and insulin was more commonly prescribed for patients of internists than for patients of general practitioners. Patients over age 35 years who are current insulin users appear to have used oral hypoglycemic agents for the first third of the duration of their diabetes (Table 7). There were few differences in insulin use by race, sex, or family income (Table 8).

The proportion of diabetics using insulin declined slightly during 1960-81, although the number of diabetics tripled during this period (Table 9). In recent years there have been some dramatic advances in the pharmacology of insulin products, including preparation of purified pork and beef insulin through removal of proinsulin and other pancreatic hormones, and manufacture of human insulin. The impact of these newer preparations on the therapy of diabetes has been impressive. In the past, with less pure preparations, the incidence of cutaneous lipohypertrophy and lipoatrophy was quite high—about 30-40 percent in women and 25 percent in men. While not associated with mortality , the morbidity of these effects was high. It predictably caused great emotional distress in people to be, in effect, disfigured by their necessary insulin therapy. In addition to this local reaction, antibodies were generated to the less pure insulin preparations, resulting in insulin allergy with classic IgE manifestations and antibody-mediated insulin resistance due to generation of IgG and IgM antibodies. With exclusive use of the newer, purer preparations, however, these complications have essentially vanished from the experience of patients with diabetes.

In addition to more pure insulin preparations, a technical breakthrough led to manufacture of human insulin from bacterial sources (Symposium 1981). The bacteria are programmed to make the A and B chains of insulin separately, which are then joined chemically. Another technology for making human insulin substitutes the terminal amino acid in pork insulin, which is the only difference from human insulin, using a chemical method efficient enough to make this feasible from a manufacturing point of view. These human insulins are still new on the diabetes treatment scene, so their full impact has not yet been appreciated, nor has there been enough prescription experience to know where these preparations will fit in the overall therapy of diabetes.

While there are numerous insulin preparations available in the United States, there are few population-based data on the frequency of their individual use. In a community-based study in Michigan in 1981-82, intermediate-acting insulin was used by the majority of diabetics. Once-daily insulin injections were about as common as more frequent injections in IDDM patients, but only 30 percent of insulin-using NIDDM patients injected insulin more than once per day (Table 12). In the United States in 1964-65, about 30 percent of diabetics had their insulin injected by someone other than themselves (Table 13). Table 14 presents knowledge and behavior data indicating that insulin-using diabetics have some accurate knowledge but that a certain amount of misinformation about insulin exists. About half of insulin users reported that they had had an insulin reaction.

TABLE 12. *Percent of insulin-using diabetics in eight Michigan communities by frequency and type of insulin injection, 1981-82*

	Insulin-dependent (N=56)	Noninsulin-dependent, Insulin-using (N=188)
Once daily	52	70
Twice or more per day	48	30
Intermediate only	66	84
Short and intermediate	34	16

SOURCE: Hiss, RG. Analysis of community diabetes care. Unpublished paper presented at the Diabetes Research and Training Centers meeting, June 1983. Based on 428 diabetics in the private practice of 61 physicians, with about 7 diabetics selected from each practice.

TABLE 13. *Percent of diabetics who use insulin, by who injects insulin, United States, 1964-65*

Who Injects Insulin	Both Sexes	Male	Female
Self	77.5	77.3	77.4
Spouse or relative	20.0	20.3	19.7
Other	2.5	2.0	2.6

SOURCE: National Center for Health Statistics. "Characteristics of Persons with Diabetes, U.S., July 1964-June 1965." Vital and Health Statistics Series 10, Number 40, October 1967.

TABLE 14. *Percent of diabetics by use of a diabetic identification and by knowledge of insulin and exercise, United States, 1976*

	Never Used Insulin	Have Used Insulin
All diabetics		
Carry/wear something that identifies them as diabetic	22	61
Think a diabetic can exercise as much as other people	52	52
Say they know what an insulin reaction is	43	78
Say they have had an insulin reaction	-	54
Diabetics who say they know what an insulin reaction is		
Think it is the same as a diabetic coma	22	13
Think it can be caused by too much food	37	27
Think it can be caused by too much exercise	23	55

SOURCE: Drury, TF, National Diabetes Data Group, from unpublished data of the 1976 National Health Interview Survey, National Center for Health Statistics.

INSULIN PUMP THERAPY

In the past decade, mechanical delivery systems for administering insulin—"pumps"—have been introduced to clinical practice. These insulin pumps are of two basic types. Open loop systems inject insulin subcutaneously as dictated by a program derived from antecedent blood glucose values. The patient receives a 24-hour continuous infusion of short-acting insulin subcutaneously and, additionally, boluses of regular insulin before meals (Mecklenburg et al. 1982). This is done to mimic secretion of insulin by normal beta cells, with the expectation that this will match normal physiology. Closed loop systems are more complicated and have a computer on line that is programmed to evaluate blood glucose concentration and modify the infusion of insulin (or glucose). Although the exact number of insulin pumps currently in use is not known, as of 1982 in the United States about 6,000 had been sold, by four manufacturers (Teutsch et al. 1984).

Insulin pumps should not be used casually; they demand substantial commitment from both the patient and the health care provider team. Patients on these devices need ongoing, careful evaluation. The use of pumps has obvious appeal because of the flexibility they can provide to a patient's lifestyle, but they do not represent an ideal treatment for all patients. Further, several studies have demonstrated that a comparable degree of blood glucose control can be achieved by multiple injection regimens and insulin pump therapy (Skyler et al. 1982). In addition, there are problems associated with use of insulin pumps. Besides the expenses of the pump itself and requisite supplies, infections can occur at the site of the indwelling needle, although this problem can be minimized by changing the site of needle placement every 24 to 48 hours. Such cutaneous infections at the site of insulin injection are quite rare with standard insulin therapy. Another complication is the occurrence of diabetic ketoacidosis. This may seem paradoxical for a form of "intensive" insulin therapy, but if insulin delivery via the pump should stop for any reason, there is no subcutaneous reservoir of intermediate-acting insulin, and the patient becomes metabolically vulnerable very quickly. Insulin pumps appear to be safe, and currently available models have features designed to protect the user both from an unsuspected failure to deliver insulin and from "pump runaways" with resultant hypoglycemia. In 1981-82, 35 deaths were observed among approximately 3,500 pump users in the United States (Teutsch et al. 1984). This did not appear to be an excess death rate in this population, however. The group of pump users who had a fatal outcome were older, had had diabetes for longer duration, and had more diabetic complications than the comparison group of pump users, which emphasizes the need for appropriate patient selection. Finally, there is another potential problem with insulin pump therapy. Laboratory animals with implanted pumps have developed fatal amyloidosis (Albisser et al. 1983). In humans using non-implanted open-loop systems, increased blood levels of amyloid precursors have been noted (Brownlee et al. 1984) and, while there have been no reports of systemic amyloidosis in human pump users, this aspect must be watched for with appropriate scrutiny.

BLOOD GLUCOSE MONITORING AND CONTROL

An important aspect of therapy of diabetes is evaluation of the patient's glycemic control. In the past, this has typically involved home testing of urine for glucose and episodic measurements of blood glucose at a physician's office or laboratory. Urine testing has been done for decades, and about three-fourths of diabetics surveyed in 1976-80 had been told by a physician that they had glycosuria. This condition was rare in persons with normal glucose tolerance (Table 15). Urine glucose testing provides an evaluation of the elevation of blood glucose by semiquantitating the glucose concentration in urine (Symposium 1981, Malone et al. 1976). This, of course, only measures the level of blood glucose above the renal threshold and is at best only a fair estimate of ongoing hyperglycemia. It is not known how frequently urine glucose testing occurs during visits to physicians or other encounters with the health care system. With regard to urine glucose testing by diabetics themselves, half of diabetics in a community-based survey in Michigan were told to test their urine daily, but only about two-thirds of these (38 percent of all diabetics) complied with these instructions (Table 16). Another study, which differentiated diabetics on insulin from those not on insulin, found that the former were more likely to test their urine glucose than diabetics not using insulin (78 percent versus 52 percent) (Table 17). This survey contained a larger proportion of insulin-using diabetics than found in the general diabetic population (Table 2), which may account for the proportion of those who self-tested urine glucose (63 percent) being greater than that found in the Michigan survey. The percent who self-tested urine glucose declined somewhat from 72 percent for diabetics age 0-24 years to 59 percent for age 65 years and older.

TABLE 15. *Percent of persons who report having been told by a physician that they had "sugar" in their urine, United States, 1976-80*

	Age (Years)				
Diagnostic Class	20-74	20-44	45-54	55-64	65-74
Diagnosed diabetes	74	87	70	71	71
Undiagnosed diabetes*	10	0	3	17	16
Impaired glucose tolerance*	9	19	4	8	5
Normal glucose tolerance*	3	3	3	3	2

*National Diabetes Data Group criteria applied to the results of 75-gram 2-hour oral glucose tolerance tests.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

TABLE 16. *Percent of diabetics in eight Michigan communities who practice home urine and blood glucose testing, 1981-82*

	All Diabetics	Insulin-Dependent	Noninsulin Dependent, on Insulin	All Insulin Users	Noninsulin Dependent, Not on Insulin
Number of diabetics	428	56	191	247	181
Told to test urine daily	51	-	-	-	-
Test almost always	38	-	-	-	-
Test sometimes	13	-	-	-	-
Blood glucose testers	7	29	6	11	3

SOURCE: Hiss, RG. Analysis of community diabetes care. Unpublished paper presented at the Diabetes Research and Training Centers meeting, June 1983. Based on the private practice of 61 physicians, with seven diabetics selected from each practice.

TABLE 17. *Percent of diabetics who self-test urine and blood glucose in a sample of diabetics containing 48 percent insulin users, 1983*

	Age (Years)				
	All	0-24	25-44	45-64	65+
All Diabetics					
Number of diabetics	6,015	250	1,020	2,566	2,173
Percent who use insulin	48	90	64	44	40
Self-test urine and/or blood glucose					
Urine	63	72	65	65	59
Blood - insulin users	28	55	40	26	16
- noninsulin users	5	-	13	4	2
- all diabetics*	16	58	30	13	3
Both urine and blood	10	40	19	9	4
Urine only	53	32	46	56	55
Blood only	6	18	11	4	3
Neither	31	9	24	31	38
Blood glucose testers (N=955, 85% use insulin)					
Frequency of self-testing blood glucose					
More than three times per day	9	15	10	6	5
Three times per day	8	13	10	5	3
Twice per day	18	21	17	20	10
Once per day	29	30	27	30	28
Two to six times per week	13	9	12	13	17
Once per week	11	5	9	12	16
Two to three times per month	2	1	2	3	3
Once per month	4	1	3	4	7
Less frequently than monthly	7	4	10	5	9
Duration of self-testing blood glucose*					
Less than 6 months	19	16	14	24	25
6-12 months	24	25	22	29	18
12-24 months	25	27	29	21	25
Over 24 months	31	32	35	25	32
Income level		All U.S.			
Less than $10,000	19	21			
$10,000 - $17,500	17	19			
$17,500 - $25,000	15	15			
$25,000 - $35,000	21	18			
More than $35,000	29	26			

*There was no difference by sex in the proportion of those who self-test blood glucose. There was also no difference between insulin users and nonusers in the duration of testing.

SOURCE: Chanoch, L. Unpublished study commissioned by Miles/Ames, Elkhart, Indiana, conducted by NFO Research, Inc., in August-October 1983. Of 8,998 U.S. households believed to contain diabetic family members, 7,158 (80%) returned the mailed questionnaire and 6,015 persons identified themselves as diabetic. While 48% of diabetics were insulin users in this study, only 25% are users in national household interview surveys.

Traditionally, blood glucose tests in diabetics have been done in a physician's office or at a nearby laboratory. However, the frequency of these tests is not well documented. In 10 percent of visits to physicians' offices in 1977, a blood glucose level determination was the principal reason for the visit (Ezzati 1980). In a small survey in Michigan in 1981-82, 85 percent of diabetics reported that they had their blood glucose tested one or more times per year, but only 13 percent averaged one glucose test per month (Table 18). Most of those who were not currently under a physician's care for their diabetes nevertheless reported they had had their blood glucose tested. Having only occasional blood glucose determinations allows only a feeble insight into the swings of blood glucose levels that most diabetic patients have, even within several hours.

TABLE 18. *Frequency of blood glucose tests in diabetics age 18 years and older, Michigan, 1980*

Number of Blood Glucose Tests Per Year	Percent of All Diabetics*
None	9
One	17
Two	13
Three	8
Four to eleven	34
Twelve or more	13
Unknown	6

*Based on 189 persons reporting a medical history of diabetes among 3,073 persons responding to a household interview survey; 25 percent were insulin users.

SOURCE: Halpern, M, DL Dodson, and J Beasley. Diabetes in Michigan: 1980 Survey Results. Michigan Department of Public Health, Division of Chronic Disease Control, Lansing, Michigan, September 1983.

An important advance in recent years has been the use of various devices to measure capillary blood glucose by patients themselves or a family member on a daily or even more frequent basis. This technique, home blood glucose monitoring, has made a dramatic impact on diabetes care (Barbosa et al. 1980, Sonksen 1978). All intensive approaches to insulin therapy, including insulin pump therapy, require that blood glucose level be known on an ongoing basis so that physician and patient can make constant adjustments in the amount of insulin administered. Home blood glucose monitoring has been central to efforts to produce day-long normalization of blood glucose level. In home glucose monitoring, a drop of blood from a fingertip is placed on a chemically impregnated strip that changes color to a degree dependent on the blood glucose concentration. Blood glucose level is estimated by comparing the developed strip to a color chart or, more exactly, by using a reflectance meter to read the strip. This technique, while achieving reasonable quantitation of blood glucose, does require a certain amount of motivation, manual dexterity, and financial commitment by the patient. The physician and patient who elect this modality must be prepared to commit themselves to evaluation of the efficacy of the testing and to using the data derived for decisions regarding manipulation of the insulin regimen.

Measurement of glucosylated hemoglobin is a relatively new means of assessment of glycemic control (NDDG 1984). The amount of glucosylation is in proportion to the ambient blood glucose concentration during the preceding several months and is a measure of the average blood glucose level for that period. Clinical uses of glucosylated hemoglobin measurement include identification of patients with poor metabolic control in whom this suboptimal control was unsuspected (Nathan et al. 1984), serving as an objective indicator of response of blood glucose levels to changes in therapy, and providing a definitive therapeutic goal for patient and physician. Its use has become widespread in academic centers and in the offices of physicians who treat diabetics, but its impact on the medical community at large is not clear.

Self-monitoring of blood glucose is not yet a common phenomenon. In a survey of Vermont pediatricians, only 18 percent recommended regular home blood glucose testing for their patients and 70 percent stated that urine testing alone is adequate for assessing glucose control (ADA 1982). Only about 3 to 5 percent of diabetics not using insulin test their own blood glucose, according to a community-based study in Michigan and a survey of diabetics in United States households, although the proportion reached 13 percent in the age group 25-44 years (Tables 16 and 17). The rate of blood glucose testing among insulin-using diabetics was about five times higher than among nonusers in each study. The proportion was highest in the youngest group of insulin-users (55 percent) and declined with age (Table 17). Among blood glucose testers in the household survey (of whom 85 percent were on insulin), 64 percent tested their blood glucose one or more times daily, and an additional 24 percent tested it one to six times per week. Very different rates were found in a small Michigan study, where only 13 percent of diabetics reported that their blood glucose was tested once a month or more often (Table 18); it is not known what proportion of these tests involved home glucose monitoring. This lower frequency may be explained in part by the fact that only 25 percent of Michigan diabetics used insulin, whereas in the household study 85 percent of blood glucose testers used insulin.

Self-testing of blood glucose is also a fairly recent phenomenon, as only 31 percent of testers had employed this technique for two years or more (Table 17). Data on the distribution of testers by family income are presented in Table 18. There was no significant difference between family income of testers and of all United States households.

Tables 19-21 are presented to provide data on glucose levels of diabetics in some community-based studies. In Minnesota, the vast majority of diabetics were maintaining their fasting blood glucose below 200 mg/dl, and the median value for all diabetics was 116 mg/dl (Table 19). In Michigan, random blood glucose values were similar between IDDM and insulin-using NIDDM patients, except that about twice as many IDDM values were greater than 300 mg/dl. For both, about one-fourth of values were below 140 mg/dl. Much lower glucose levels were recorded for NIDDM patients not on insulin, and their better glucose control was probably the reason that these patients were not yet placed on insulin (Table 20). In a Wisconsin population of NIDDM patients, about twice as many values of insulin users were in the worst glucose range

TABLE 19. *Fasting blood glucose values of diabetics, Rochester, Minnesota, 1970*

Median blood glucose	116 mg/dl
Percent distribution:	
<200 mg/dl	86
200-299 mg/dl	11
300+ mg/dl	3

SOURCE: Melton, LJ, et al. Referral bias in diabetes research. Diabetes Care 7:12-18, 1984.

compared to diabetics using oral agents, which is similar to the Michigan population. However, patients on neither therapy also had a large proportion of their values in the worst glucose ranges. Glucose control deteriorated with increasing duration of diabetes, but was better for older-onset patients than younger-onset patients (Table 21).

TABLE 20. *Percent of diabetics in eight Michigan communities by blood glucose and glycosylated hemoglobin levels, 1981-1982*

		Noninsulin-dependent	
	Insulin-Dependent (N=56)	Using Insulin (N=191)	Not Using Insulin (N=181)
Blood glucose			
40-140 mg/dl	25	29	58
140-240 mg/dl	39	34	31
240-300 mg/dl	11	24	7
>300 mg/dl	25	13	4
HbA_1 <7.5%	11	10	9
Mean duration of diabetes	21 years	12 years	8 years

SOURCE: Hiss, RG. Analysis of community diabetes care. Unpublished paper presented at the Diabetes Research and Training Centers meeting, June 1983. Based on the private practice of 61 physicians, with about 7 diabetics selected from each practice. Total number of diabetics = 428.

TABLE 21. *Percent* of diabetic patients age 30+ years at diagnosis by blood glucose control index, southern Wisconsin, 1979-80*

	Index: Number of Glucose Measurements Greater Than Criteria**				
	0/4	1/3,1/4	2/4	2/3,3/4	3/3,4/4
Therapy					
Insulin	10	15	16	24	35
Oral hypoglycemic agents	16	16	14	20	17
Neither	29	16	15	35	35
Age at diagnosis (years)					
30-49	12	-	-	-	38
50-69	18	-	-	-	31
70+	21	-	-	-	26
Duration of diabetes (years)					
0-4	19	-	-	-	27
5-9	18	-	-	-	34
10-14	12	-	-	-	39
15+	9	-	-	-	34

*Given as percent of row total.

**Measurements: fasting and casual blood glucose; criteria: fasting = 140 mg/dl, casual = 200 mg/dl.

SOURCE: Klein, R, et al. Hypoglycemic therapy in patients diagnosed to have diabetes at 30 years of age or older. J Chronic Dis 37:159-65, 1984.

PANCREATIC TRANSPLANTATION

Pancreatic transplantation for patients with diabetes is still an experimental procedure. Animal studies in this area have been successful, and animals made diabetic can be restored to normal glucose metabolism by transplantation of islets derived from isogenic litter mates. This ensures an adequate number of islets available for injection and obviates the need for immunosuppression. Pancreatic transplantation in humans has been less successful. Transplantation of pure islet cell preparations has not resulted in functioning grafts in people, and the trend has been toward whole or segmental organ transplant in recent years. The number of islets that survive in a cadaver transplant may be limited, and a section of pancreas from a living related donor may not provide a sufficient number of functioning beta cells to adequately control blood glucose in the recipient. Immunosuppression has generally been used in persons receiving a pancreatic transplant, in part because many of these patients have also received renal allografts for which immunosuppression is standard. Many immunosuppressive regimens include use of prednisone, which is diabetogenic. Recently, pancreatic transplantation was performed in pairs of twins, with the nondiabetic twin providing a segmental allograft for the diabetic co-twin. Distressingly, these transplants were rejected, indicating that the autoimmune destructive process that had affected the diabetic's islets could similarly destroy the transplanted organ (Sutherland et al. 1984b).

In 1966 a pancreas transplant registry was formed, and in 1977 an international registry was established. Between 1966 and 1982, there have been 207 grafts in 193 patients. As of March 1982, 13 percent of these patients had functioning grafts and were insulin-independent (Table 22). Of the 181 nonfunctioning grafts, 51 failed for purely technical reasons, 89 failed because of rejection or for unknown reasons, and 41 patients died with functioning grafts. Many of the grafts were associated with kidney transplants.

TABLE 22. *Pancreas transplants, 1966-82*

Type of Transplant	Number of Cases	Currently Functioning as of March 1982	
		Number	Percent
Segmental pancreas alone	54	3	6
Pancreaticoduodenal alone	6	0	0
Whole pancreas alone	1	0	0
Segmental pancreas with simultaneous kidney	73	13	18
Pancreaticoduodenal with simultaneous kidney	21	0	0
Segmental pancreas after previous kidney	42	9	21
Whole pancreas after previous kidney	2	1	50
Segmental pancreas with subsequent kidney	8	0	0
Total	207	26	13

SOURCE: Combined data of ACS/NIH Organ Transplant Registry and New Pancreas Transplant Registry.

OTHER DRUGS PRESCRIBED FOR DIABETICS

Diabetics are known to have many diseases and conditions other than diabetes, and drugs other than insulin and oral hypoglycemic agents are part of the therapeutic management of diabetic patients. Drug use by diabetics appears to be significantly higher than by nondiabetics. In a 1977-78 study of 2,836 diabetic outpatients in Public Health Service clinics, use of most drugs was higher among diabetics in all age groups (Table 23). During 9.6 million office visits to physicians for diabetes in 1980, one or more drugs were prescribed during 80 percent of these visits, and an average of 1.8 drugs were prescribed per visit (NCHS 1980). Among diabetic patients of a sample of physicians in Indiana, 18 percent of prescribed drugs were omitted by patients and 19 percent of diabetics were using more drugs than their physicians prescribed (Hulka et al. 1973). No consistent pattern of these drug errors in relation to patient characteristics or measure of diabetes severity was found. Table 24 further illustrates that diagnosed diabetics use more medications than persons with lesser glucose tolerance or with normal glucose tolerance.

TABLE 23. *Percent of outpatients who were prescribed certain drugs, United States Public Health Service clinics, 1979-81*

	Age (Years)						
	Diabetics			Nondiabetics			
Drugs	<30	61-70	All	<30	61-70	All	All Ratio
Number of patients	256	623	2,773	40,070	6,126	84,543	
Antibiotics							
Antituberculosis	0.8	0.2	0.4	0.2	0.4	0.2	1.8
Antihelminthic	0.4	0.2	0.1	0.0	0.0	0.0	3.5
Antifungal (systemic)	1.6	1.6	2.1	0.8	1.0	1.0	2.3
Antimalarial	0.0	3.0	1.8	0.1	1.6	0.4	2.1
Urinary antiseptics	0.8	1.6	1.8	0.7	1.3	0.9	4.7
Topical antibiotics	3.9	5.6	4.9	1.6	1.4	1.5	1.9
Topical antifungals	4.7	6.7	6.1	2.3	2.9	2.6	3.2
Miscellaneous	18.4	17.2	17.6	14.2	12.1	13.0	2.3
Sulfonamides	2.7	3.7	3.4	1.3	2.3	1.6	1.4
Central nervous system drugs							
Anticonvulsants	0.8	3.1	1.8	0.4	1.6	0.7	2.4
Antiparkinsonian	2.0	4.0	3.8	0.8	2.0	1.4	2.8
Antipsychotics	0.8	4.5	3.2	0.2	1.1	0.6	5.4
Antidepressants	0.8	6.0	4.1	0.5	2.1	1.8	2.5
Sedatives							
Barbiturate	0.8	10.1	7.3	0.4	4.6	1.6	4.5
Nonbarbiturate	4.7	21.7	20.2	2.9	12.3	7.0	2.9
Ergot derivatives	0.4	0.0	0.4	0.1	0.2	0.2	1.9
Stimulants	0.0	0.2	0.3	0.1	0.1	0.1	2.3
Muscle relaxants	1.6	3.1	2.6	1.3	2.0	1.9	1.4

(Continued)

TABLE 23. (Continued)

Drugs	Age (Years)						All Ratio
	Diabetics			Nondiabetics			
	<30	61-70	All	<30	61-70	All	
Cardiovascular drugs							
Antiarrhythmics	0.4	4.7	3.0	0.1	2.4	0.7	4.7
Antianginal	1.2	24.1	17.2	0.2	11.1	3.3	5.3
Anticoagulants	0.0	1.9	1.3	0.0	0.6	0.2	5.9
Digitalis	0.4	18.1	10.3	0.1	5.7	1.4	7.4
Antihypertensives	2.0	27.3	22.7	0.2	11.0	3.6	6.4
Diuretics	6.3	51.5	42.4	0.8	25.7	8.9	4.7
Gastrointestinal drugs							
Anticholinergics	0.8	0.8	1.3	0.4	1.0	0.6	2.0
Antidiarrheal	0.4	3.7	2.8	1.6	1.9	1.6	1.7
Antiemetics	3.1	3.7	2.9	0.9	2.1	1.2	2.4
Antiulcer	5.5	23.1	18.3	3.0	12.7	6.4	2.9
Digestives (saccharin)	0.4	2.1	2.3	0.2	1.4	3.3	3.8
Laxatives	3.1	14.8	12.5	1.3	8.8	0.5	4.3
Eye, ear, nose, throat, and pulmonary drugs							
Ear	0.8	0.5	0.7	0.4	0.4	0.3	2.2
Eye	10.6	16.4	11.9	5.4	9.8	6.1	2.0
Decongestants	0.4	1.3	0.8	0.3	0.4	0.3	2.6
Lozenges	6.3	4.7	4.9	5.2	2.9	4.1	1.2
Cough medicine	14.5	17.7	16.7	10.6	11.4	10.0	1.7
Antihistamines	19.9	17.2	18.4	14.2	12.1	12.6	1.5
Antiasthmatics	9.0	11.2	10.9	7.2	8.5	6.9	1.6
Pain medications							
Analgesics	26.6	45.1	38.2	18.5	26.0	20.6	1.8
Narcotics	2.0	7.4	6.8	2.3	3.7	2.9	2.3
Anti-inflammatory agents							
Systemic steroids	2.3	3.7	2.6	0.5	1.8	0.9	3.0
Nonsteroidal	2.0	16.1	12.2	1.2	10.6	4.3	2.8
Antigout	0.4	7.7	6.1	0.3	4.1	1.3	4.6
Antilipemic	0.8	3.5	2.1	0.0	0.9	0.2	8.7
Sex hormones	19.1	4.7	7.3	4.4	2.9	4.0	1.8
Thyroid drugs	2.0	2.7	3.4	0.2	2.2	0.9	4.0
Topical preparations							
Acne	2.3	0.5	0.6	1.3	0.2	0.8	0.7
Psoriasis	0.4	1.0	0.6	0.7	0.7	0.5	1.2
Emollients	2.0	3.1	3.1	0.8	1.4	0.8	3.9
Steroids	12.9	16.7	15.0	5.4	10.2	6.5	2.3
Scalp	3.1	2.9	2.5	1.1	1.4	1.2	2.2
Miscellaneous	10.6	15.6	12.7	3.4	5.9	4.5	2.8
Miscellaneous agents							
Antineoplastics	0.4	1.9	1.5	0.4	0.7	1.4	1.7
Diagnostic agents (Clinitest, PPD)	12.1	35.8	31.4	1.2	0.5	0.8	39.3
Hematinics	2.3	2.9	2.3	1.6	1.2	1.4	1.7
Serums, vaccines	11.3	5.9	4.9	2.7	2.3	2.0	2.5
Vitamins	12.1	27.8	23.0	5.4	13.7	7.2	3.2

SOURCE: Rendell, M, et al. A pharmaceutical profile of diabetic patients. J Chronic Dis 36:193-202, 1983.

TABLE 24. *Percent of persons by number of medications used and glucose tolerance status, United States, 1976-80*

	Number of Medications				
	None	One	Two	Three	Four or More
Diagnosed diabetics	14	29	18	14	24
Undiagnosed diabetics*	27	30	20	11	12
Impaired glucose tolerance*	32	29	24	6	8
Normal glucose tolerance*	47	28	14	6	5

*National Diabetes Data Group criteria applied to the results of 75-gram 2-hour oral glucose tolerance tests.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

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APPENDIX A. *Percent of diagnosed diabetics by current and previous diabetes therapies and current age, United States, 1976*

Therapy	Age (Years)			
	All	20-39	40-59	60+
Currently using insulin	22.3	31.0	22.7	17.7
Used insulin for most of the past year	21.2	29.0	21.9	17.3
Ever used insulin	29.7	36.3	31.2	25.0
Currently using diabetes pills	40.1	14.7	36.1	50.1
Used pills for most of the past year	41.9	14.3	38.8	51.6
Ever used diabetes pills	67.5	37.8	67.6	75.0
Currently using a written diet	53.0	50.4	53.8	53.1
Using diet only	18.6	27.1	19.9	16.6
Using insulin and written diet	14.5	16.2	15.1	10.8
Using pills and written diet	20.6	7.1	18.8	25.7
Ever given a written diet	80.4	84.1	83.1	77.8
Not currently using insulin/pills/diet	19.0	27.6	21.3	15.6

SOURCE: National Diabetes Data Group, from data on 2,442 persons who reported a physician's diagnosis of diabetes in the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX B. *Percent of diabetics by diabetes therapy and age at diagnosis, United States, 1976*

Therapy	Age at Diagnosis (Years)			
	20-39	40-49	50-59	60+
Current therapy				
Insulin	29.8	26.0	16.5	9.6
Oral hypoglycemics	24.2	40.9	51.3	53.0
Diet	58.1	54.5	52.7	54.0
None of the above	22.9	18.6	14.4	18.2
Ever used				
Insulin	38.3	37.7	24.2	15.9
Oral hypoglycemics	52.3	74.1	75.6	73.4
Diet	85.5	83.1	82.2	75.5

SOURCE: National Diabetes Data Group, from data on 2,442 persons who reported a physician's diagnosis of diabetes in the 1976 National Health Interview Survey, National Center for Health Statistics.

APPENDIX C. *Percent of diabetics by medication at the time of the survey, United States, 1964-65*

Age (Years)	Insulin Only	Oral Drugs Only	Neither
All	25.7	48.4	24.0
25-44	30.2	31.3	35.9
45-54	24.9	48.8	23.9
55-64	21.1	55.7	21.2
65-74	23.4	53.1	21.6
75+	20.7	54.7	23.0

SOURCE: Bauer, ML. Characteristics of persons with diabetes. National Center for Health Statistics, Vital and Health Statistics Series 10, No. 40, October 1967.

APPENDIX D. *Percent of diagnosed diabetics age 12-74 years by current and previous diabetes therapies and by sex and race, United States, 1976-80*

Therapy	Age 12-74 Years	White		Black	
		Males	Females	Males	Females
Currently using insulin	26.4	23.9	24.5	38.3	36.5
Used insulin for most of the past year	25.1	21.6	24.2	34.4	36.4
Ever used insulin	34.4	32.6	30.8	50.9	47.9
Currently using diabetes pills	34.8	37.4	34.5	18.4	36.7
Used pills for most of the past year	33.9	37.6	32.9	18.2	35.4
Ever used diabetes pills	65.0	70.7	61.2	52.9	71.0
Currently using a written diet	48.0	45.5	48.9	45.3	53.6
Using diet only	14.2	11.7	16.4	15.0	12.3
Using insulin and written diet	17.5	17.3	15.5	21.2	25.4
Using pills and written diet	16.3	16.6	17.0	9.2	15.8
Ever given a written diet	75.1	72.8	77.6	73.5	72.3
Not currently using insulin/pills/diet	24.7	27.1	24.5	28.3	14.5
Ever used insulin	2.3	1.6	2.8	2.7	1.8
Ever used diabetes pills	8.3	10.8	5.7	8.5	12.2

SOURCE: Harris, MI, National Diabetes Data Group, from data on 756 persons who reported a physician's diagnosis of diabetes in the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics.

APPENDIX E. *Percent of diabetics who were given a diet and who follow diet, United States, 1964-65*

Age (Years)	Given Diet			Follow Diet		
	Both Sexes	Male	Female	Both Sexes	Male	Female
All	77.1	72.8	80.3	52.7	48.5	55.9
Under 25	70.3	61.1	78.9	47.7	38.9	56.1
25-44	78.3	77.0	78.2	51.6	49.6	53.1
45-54	76.9	71.4	81.2	52.5	53.4	51.6
55-64	82.8	78.0	86.0	58.8	53.1	62.8
65-74	77.9	72.2	81.5	52.5	45.6	56.8
75+	66.0	64.5	67.0	44.7	41.3	46.9

SOURCE: Bauer, ML. Characteristics of persons with diabetes. National Center for Health Statistics, Vital and Health Statistics Series 10, No. 40, October, 1967.

APPENDIX F. *Therapeutic modalities in 14,000 diabetic children cared for by 68 pediatric diabetologists, United States, 1980-82*

Insulin	Percent
NPH	88
Lente	12
Single daily injection	23
Twice daily injection	70
Insulin pump	5
Diet	
Calorie restricted-exchange system	77
Calorie restricted with low saturated fats	76
Normal diet for age	58
Glucose Monitoring	
Urine only	>50
3 times per day	40
4 times per day	24
Blood glucose at home	<25

SOURCE: Clarke, WL, AL Snyder, G Nowacek. Outpatient pediatric diabetes. J Chron Dis 38:85-90, 1985.

APPENDIX G. *Dietary habits of diabetics: Percent of diabetics (DM) and nondiabetics (nonDM) who eat breakfast and snack between and after meals, United States, 1977*

	Age (Years)							
	20+		20-44		45-64		65+	
	DM	nonDM	DM	nonDM	DM	nonDM	DM	nonDM
Eat breakfast								
Every day	80	57	59	44	80	66	90	86
Sometimes	8	16	15	21	10	12	3	6
Rarely or never	11	27	25	35	10	22	6	8
Snack between/after meals								
Every day	35	38	39	42	38	35	30	28
Sometimes	24	27	32	31	22	25	23	21
Rarely or never	40	34	28	27	39	40	48	51

SOURCE: 1977 National Health Interview Survey, National Center for Health Statistics.

APPENDIX H. *Number of prescriptions (thousands) for hypoglycemic drugs prescribed by physicians during office visits for diabetes,* United States, 1980 and 1981*

Drug	1980	1981
Insulin	5,248	5,314
Diabinese (chlorpropamide)	3,204	2,876
Orinase (tolbutamide)	1,352	1,146
Tolinase (tolazamide)	870	1,188
Dymelor (acetohexamide)	-	377

*Approximately 16 million visits for diabetes to physicians' offices occurred in each year.

SOURCE: Koch, H. Drugs most frequently used in office-based practice. National Center for Health Statistics, Vital and Health Statistics Advance Data, No. 78, May 12, 1982; personal communication for 1981 data.

APPENDIX I. *Some insulins sold in the United States, 1983*

Brand Name	Maker	Species	Concentration
Short-Acting			
Standard			
Regular Iletin I	Lilly	Beef and pork	U40,U100
Regular	Squibb-Novo	Pork	U40,U100
Semilente Iletin I	Lilly	Beef and pork	U40,U100
Semilente	Squibb-Novo	Beef	U100
Purified			
Regular Iletin II	Lilly	Pork or beef	U100,(U500)
Purified regular	Squibb-Novo	Pork	U100
Actrapid	Novo	Pork	U100
Velosulin	Nordisk	Pork	U100
Semitard	Novo	Pork	U100
Humulin-R	Lilly	Human	U100
Actrapid human	Squibb-Novo	Human	U100
Intermediate-acting			
Standard			
NPH Iletin I	Lilly	Beef and pork	U40,U100
Lente Iletin I	Lilly	Beef and pork	U40,U100
Isophane NPH	Squibb-Novo	Beef	U40,U100
Lente	Squibb-Novo	Beef	U40,U100
Purified			
NPH Iletin II	Lilly	Pork or beef	U100
Lente Iletin II	Lilly	Pork or beef	U100
Purified Isophane NPH	Squibb-Novo	Beef	U100
Purified Lente	Squibb-Novo	Beef	U100
Protophane NPH	Novo	Pork	U100
Lentard	Novo	Pork or beef	U100
Monotard	Novo	Pork	U100
Insulatard	Nordisk	Pork	U100
Mixtard	Nordisk	Pork	U100
Humulin-N	Lilly	Human	U100
Monotard Human	Squibb-Novo	Human	U100
Long-acting			
Standard			
Ultralente Iletin I	Lilly	Beef and pork	U40,U100
PZI Iletin I	Lilly	Beef and pork	U40,U100
Ultralente	Squibb-Novo	Beef	U100
PZI	Squibb-Novo	Beef	U100
Purified			
PZI	Lilly	Pork or beef	U100
Ultratard	Novo	Beef	U100

APPENDIX J. *Some insulin infusion pump manufacturers in the United States*

BioMedical Devices, Inc.
2921 Eastlake Avenue E.
Seattle, WA 98102

Cardiac Pacemakers, Inc.
Eli Lilly and Company
4100 North Hamline Avenue
P.O. Box 43079
St. Paul, MN 55164

Flint Laboratories
Londonderry Turnpike
Hooksett, NH 03104

Markwell Medical
Institute, Inc.
P.O. Box 5173
Racine, WI 53405

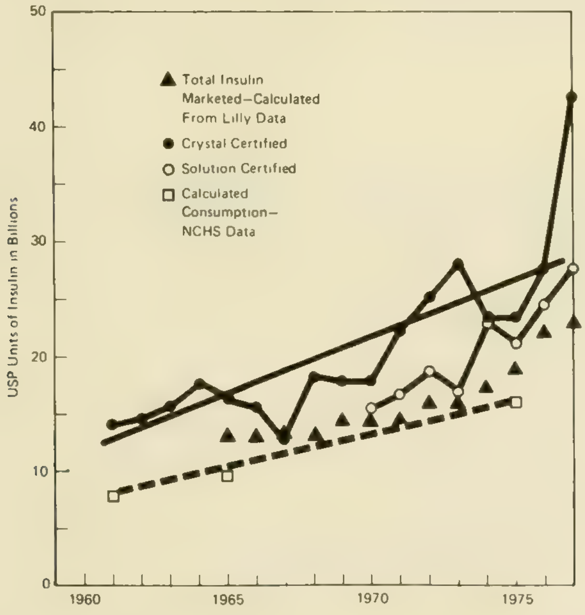
Medix Corporation
209 West Central St.
Natick, MA 01760

Orange Medical Instruments
3183 Airway Avenue
Building F
Costa Mesa, CA 92626

Pacesetter Systems, Inc.
12884 Bradley Avenue
Sylmar, CA 91342

Windsor Medical, Inc.
South Road
Enfield, CT 06082

APPENDIX K. *Various estimates of insulin demand*



SOURCE: Harris, MI, National Diabetes Data Group. Analysis of insulin supply and demand data. In: A Study of Insulin Supply and Demand. National Diabetes Advisory Board, NIH Pub. No. NIH-78-1588. April 1978.

APPENDIX L. *Some blood glucose testing products and distributors in the United States*

Name	Distributor
Finger-pricking aids	
Autoclix	Bio-Dynamics
Autolet	Ames or Ulster Scientific
Hemalet	Medprobe or Orange
Monojector	Monojet
Visually read strips	
Chemstrip bG	Bio-Dynamics
Visidex	Ames
Meters	
Accu-Chek bG	Bio-Dynamics
Glucometer	Ames
Glucoscan Plus	LifeScan

CHAPTER XXV. AMBULATORY MEDICAL CARE FOR DIABETES

Maureen I. Harris, Ph.D., M.P.H.

SUMMARY

About 13 to 16 million visits to physicians' offices were made specifically for diabetes in 1980, and an additional 3 million contacts were made with physicians in hospital clinics and emergency rooms or by telephone. These visits and contacts comprised about 1.6 percent of all outpatient physician contacts that occurred during 1980. Diabetes was the seventh leading cause of visits to office-based physicians.

About half of adult diabetics have seen a physician for their diabetes within the previous 2 to 6 months; about 10 percent have not seen a physician for their diabetes in over a year. The average number of visits to physicians for diabetes is about 3 per diabetic per year, although diabetics may make an average of between 6 and 11 total visits to physicians per person per year.

NATIONAL HEALTH SURVEYS

There are several sources of national data on ambulatory care received by diabetics. These surveys are based on stratified United States samples, either a sample of households and their residents or a sample of physicians and visits to their offices. In the National Health Interview Survey (NHIS) of the National Center for Health Statistics (NCHS), respondents to a demographic/medical history interview conducted in their homes report on their contacts with the medical care system. These contacts can be analyzed according to the diabetic status of the household member or according to the medical condition that was considered the primary reason for the contact. For example, respondents to the NHIS are queried about the primary reason for their contacts with a physician or an assistant/nurse acting under a physician's supervision. If diabetes is indicated, these contacts are coded to diabetes. However, if diabetics contacted a physician but the reason was not given as diabetes, these contacts may not be recorded as involving diabetes. Hence the physician-visit data of NHIS can be used to determine those visits that were specifically for diabetes, but unless analyzed by the diabetic status of the household member, not all visits or contacts with physicians by

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diabetics are included. A second survey with a household interview component, the 1976-80 NCHS National Health and Nutrition Examination Survey (NHANES II), also determined only physician visits that were specifically for diabetes.

In the NCHS National Ambulatory Medical Care Survey (NAMCS), physicians in office-based practices complete forms that indicate the medical conditions involved during an office visit and certain other characteristics of the visit and the patient. Physicians participating in NAMCS include non-Federal, office-based physicians engaged primarily in patient care activities, and do not include anesthesiologists, radiologists, pathologists, chiropractors, podiatrists, optometrists, or physicians practicing in Alaska or Hawaii. The NAMCS does not include telephone contacts with office-based physicians or physician encounters in hospital clinics and emergency rooms, which accounted for 19 percent of all physician contacts recorded in the 1980 NHIS. In addition, hospital-based physicians who probably represent the most skilled specialists in diabetes are not included in the survey. Since NAMCS data are visit-based, not patient-based, they probably overrepresent diabetics who frequently see physicians in their offices versus more infrequent patients. It may also overrepresent diabetics who use insulin, as insulin was prescribed in 33 percent of NAMCS visits for diabetes in 1980 (Koch 1982), while insulin-users constitute only about 25 percent of the diabetic population (Harris 1983).

In the NCHS National Medical Care Utilization and Expenditure Survey (NMCUES), a national sample of about 6,000 families containing about 17,000 persons, of whom 411 were persons who said they had diabetes, were queried five times during 1980 about their health care experiences and expenditures. Thus, all contacts by diabetics with the health care system can be ascertained from this data source, whether they were for diabetes or for some other reason.

In the National Medical Care Expenditure Survey (NMCES) of the National Center for Health Services Research, six household interviews were conducted in approximately 14,000 randomly selected households in the United States in 1977-78. Information was obtained on the use of various types of health services and associated charges, and persons in the household were also asked whether they had diabetes. As in NMCUES, all contacts by diabetics can be ascertained, whether they were for diabetes or for some other reason.

SOURCES OF AMBULATORY CARE USED BY DIABETICS

Diabetics are frequent users of the medical care system (Table 1). In addition, in virtually every category of ambulatory care (as well as hospital care) and each age group, a greater percent of diabetics than the general population used the source of care within the previous year. The most frequent location was physicians' offices, but hospital outpatient clinics or emergency rooms and telephone contacts were also significant sources of medical care. For only one medical care provider, dentists, was the proportion of persons using the service lower for diabetics than for the general population.

The 1977 NMCES data on the number of persons with an expense for certain health services can be used as a proxy for utilization of those services. Based on this survey, virtually all diabetics (94 percent) saw a physician in an ambulatory care setting in that year, and 32 percent also had nonphysician ambulatory care contacts (Table 2).

TABLE 1. *Percent of diabetics (DM) and the general population (U.S.) using specific sources of medical care during the previous 12 months, United States, 1974*

	Age (Years)							
	20+		20-44		45-64		65+	
Source of Care	DM	U.S.	DM	U.S.	DM	U.S.	DM	U.S.
Physician's office	78.4	67.4	76.6	68.2	77.2	65.4	81.1	69.1
Hospital outpatient clinic or emergency room	30.9	19.0	34.3	21.9	34.1	16.3	24.4	14.1
Short-stay hospital	22.9	12.8	23.4	12.8	23.1	11.8	22.4	14.8
Clinic	6.7	7.1	12.3	9.4	6.8	5.8	3.2	1.6
Telephone contact	17.5	13.6	26.7	15.8	15.6	11.2	14.3	10.7
Home visit	2.9	1.6	2.3	1.0	1.6	1.5	5.1	4.0
Dentist	38.3	48.8	54.1	55.0	39.9	47.5	26.3	29.0
Podiatrist	6.4	3.2	4.2	1.5	3.7	4.3	11.4	6.6
Chiropractor	5.7	5.0	6.4	4.5	6.3	6.4	4.3	4.0
Physical therapist	3.9	2.0	4.4	1.9	5.7	2.0	1.4	2.2

SOURCE: Drury, TF, from data of the 1974 National Health Interview Survey, National Center for Health Statistics.

TABLE 2. *Percent of diabetics (DM) and nondiabetics (NonDM) who had an expense in certain medical care categories, United States, 1977*

	Age (Years)							
	All		0-44		45-64		65+	
Type of Care	DM	NonDM	DM	NonDM	DM	NonDM	DM	NonDM
Ambulatory care	95.4	76.2	97.0	74.8	94.4	77.9	95.8	82.6
Physician contacts	94.0	73.4	97.0	72.0	93.3	73.8	94.6	80.1
Nonphysician contacts	31.5	17.8	28.8	15.8	31.6	21.5	32.4	24.6
Vision	15.6	10.8	12.7	8.3	17.4	17.8	14.9	14.0
Dental	29.0	42.5	41.8	43.5	30.0	44.2	23.5	31.9
Hospital care	27.5	11.3	24.8	9.5	24.5	13.6	31.4	20.1
Hospital stay	27.5	11.3	24.8	9.4	24.5	13.6	31.4	20.1
Physicians	26.9	11.0	24.2	9.1	23.1	13.3	30.5	19.5
Other	4.5	1.2	1.4	0.7	3.1	1.6	7.0	4.3

SOURCE: Meyers, S, MI Harris, T Drury, and P Entmacher, from data of the 1977 National Medical Care Expenditure Survey, Household Data, National Center for Health Services Research.

These proportions were higher in each age group for diabetics than for nondiabetics. About 16 percent of diabetics had an expense for vision care, compared to about 11 percent of nondiabetics. As in the 1974 NHIS, the proportion of diabetics using dental services was lower than that of nondiabetics (Table 2). The 1978 NHIS also documents the frequent contact of diabetics with the medical care system. In that year more than 9 of 10 diabetics reported in the NHIS that they had a regular source of medical care; the offices and clinics of physicians predominated and were identified as the regular source of care for 87 percent of diabetics ages 20 years and older (Drury et al. 1981). Only about 10 percent of diabetics with a regular source of care reported that this source was a hospital outpatient department, although this proportion varied with race and family income. For example, 5 percent of all white diabetics, but 39 percent of all poor (family income less than $7,000 in 1978) black diabetics reported that hospital outpatient departments were their regular source of medical care in 1978 (Drury et al. 1981).

NUMBER OF AMBULATORY PHYSICIAN VISITS FOR DIABETES

In the 1980 NHIS, there were about 16.9 million outpatient contacts with physicians for diagnosis and treatment of diabetes, representing 1.6 percent of all outpatient physician contacts that occurred in the United States (Table 3). This percent has varied somewhat throughout the past decade. Of the physician contacts specifically for diabetes, almost 80 percent were in physicians' offices, with the remainder about equally divided between hospital clinic/emergency rooms and telephone contacts (Table 3).

TABLE 3. *Number (millions) of outpatient contacts with physicians for all reasons and for diagnosis and treatment of diabetes, United States, 1971-80*

		All Physician Contacts in U.S.*		All Contacts with Diabetes as the Primary Diagnosis		Primary Diagnosis of Diabetes as Percent of All Contacts
Year	Place of Contact	Number	Percent	Number	Percent	
1971	All contacts	999	-	12.8	-	1.3
1975	All contacts	1,056	-	19.4	-	1.8
1980	All contacts	1,036	100.0	16.9	100.0	1.6
	Physicians' offices	703	67.9	13.3	78.9	
	Hospital clinic or emergency room	134	12.9	1.7	10.1	
	Telephone	126	12.2	1.4	8.5	
	Other or unknown	73	7.0	0.4	2.6	

*Includes all visits for diagnosis and treatment (84.4 percent of all visits in 1980), plus contacts for pre/postnatal care (3.9 percent), general checkup (8.3 percent), immunization/vaccination (1.9 percent), other (3.0 percent). Excludes contacts with physicians by persons who were inpatients in hospitals.

SOURCE: National Health Interview Surveys, National Center for Health Statistics.

In the 1980 NAMCS, there were about 9.55 million visits for diabetes as the primary diagnosis to certain office-based physicians (Table 4), compared to the 13.3 million visits specifically for diabetes in physicians' offices estimated from the 1980 NHIS. In the NAMCS, there were also 6.7 million visits in which diabetes was a secondary diagnosis, for a total of 16.25 million. These secondary diagnoses are not tabulated in the NHIS. Of all 576 million visits to office-based physicians recorded in the 1980 NAMCS survey, 2.82 percent involved diabetes (Table 5). The number of diabetes visits, and the percent of all physician visits represented by diabetes, increased with patient age, as might be expected in view of the increasing prevalence of diabetes with age.

TABLE 4. *Annual number (millions) of visits to office-based physicians for all conditions and for diabetes, United States, 1973-81*

Year	Total Visits for All Conditions	Diabetes Diagnosis in Visits for Diabetes		
		Primary	Secondary	All
1973-74	645	8.9	-	-
1975	568	9.7	-	-
1976	588	9.6	-	-
1977	570	11.0	7.8	18.8
1979	556	8.9	-	-
1980	576	9.55	6.7	16.3
1981	585	10.8	-	-

SOURCE: National Ambulatory Medical Care Surveys, National Center for Health Statistics.

TABLE 5. *Number and percent of office-based physician visits involving diabetes, by age of patient, compared to the age-specific prevalence of diabetes*

Age (Years)	Thousands of Visits for Diabetes*	Percent of All Visits to Physicians	Percent of U.S. Population with DM	Ratio, Percent of All Visits to Percent of Population with Diabetes
All	16,247	2.82	2.47	1.1
0-24	1,365	0.66	0.18	3.7
25-44	1,581	1.02	1.20	0.9
45-54	2,610	4.24	4.28	1.0
55-64	4,224	6.19	6.81	0.9
65-74	4,728	7.76	8.77	0.9
75+	1,738	7.16	8.94	0.8

*Includes all visits in which diabetes was listed on the patient record form.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1980 National Ambulatory Medical Care Survey and the 1979-81 National Health Interview Surveys, National Center for Health Statistics.

FREQUENCY OF AMBULATORY VISITS TO PHYSICIANS FOR DIABETES

In the 1976-80 NHANES, almost half of adults with a medical history of diabetes had seen a physician for their diabetes within the previous month and another third within the previous 2 to 6 months (Table 6). Less than 10 percent had not consulted a physician for their diabetes in over a year. In the 1976 NHIS, similar physician-visit frequencies were found.

Several studies and surveys provide estimates of the average annual number of visits to physicians by diabetics (Table 7). Based on the 16.9 million physician contacts in the 1980 NHIS and the estimated diabetes prevalence of 5.5 million persons in 1980 (Drury and Harris 1984), an average of 3.1 visits per diabetic per year specifically for diagnosis and treatment of diabetes can be calculated. Using the 1980 NAMCS estimate of 16.25 million visits to office-based physicians in which diabetes was recorded as a diagnosis results in a similar average of 3 visits for diabetes per diabetic per year. The NMCUES, which recorded all contacts with physicians, estimated that diabetics made 6 visits per person in 1980, compared to 2.7 visits per nondiabetic in that year. A 1981-82 community-based study in Michigan also estimated that diabetics made about 6 visits to physicians per year, although the 1976 and 1979-81 NHIS indicated that diabetics made 10-11 contacts with physicians for all reasons annually (Drury et al. 1981).

CHARACTERISTICS OF PHYSICIAN VISITS FOR DIABETES IN NAMCS

Visits to one physician specialty, general practice, comprised about half of NAMCS physician visits for diabetes in 1980 (Table 8). This proportion of diabetes visits to general practitioners, who might be considered to be relatively unspecialized in the

TABLE 6. *Percent of persons with diabetes, by time interval since last physician visit for diabetes, in two United States surveys*

	Age (Years)			
	20-44	45-54	55-64	65-74
1976-80 NHANES				
Within previous month	34	44	45	57
1-6 months ago	37	31	35	31
7-12 months ago	14	17	11	6
More than 12 months ago	15	8	9	6
1976 NHIS	20-44	45-64	65+	
1-5 months ago	61	69	74	
6-11 months ago	13	14	8	
12-23 months ago	11	6	6	
2-4 years ago	7	5	4	
5 years ago and over	2	2	2	
Never	1	0	0	
Unknown	6	4	5	

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976-80 National Health and Nutrition Examination Survey, National Center for Health Statistics; and Drury, TF, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

TABLE 7. *Estimates of the average number of visits to physicians per diabetic per year, United States, 1976-82*

Year and Source*	Diabetes as Primary Reason for the Visit	Diabetes as Other Reason for the Visit	Any Visit by a Diabetic
1976 NHIS	-	-	11
1979-81 NHIS	-	-	10
1980 NHIS	3.1	-	-
1980 NAMCS	1.7	1.2	-
1980 NMCUES	-	-	6
1981-82, Michigan	-	-	6

*NHIS, NAMCS, and NMCUES are surveys from the National Center for Health Statistics. The Michigan data are estimated from Hiss, RG, Analysis of community diabetes care, presented at the Diabetes Research and Training Centers meeting, San Antonio, June 1983.

TABLE 8. *Number (thousands) and percent distribution of all visits and visits for diabetes* to office-based physicians, by physician specialty and patient age, United States, 1980*

	Age (Years)							
	All				0-44			
	All Visits		DM Visits		All Visits		DM Visits	
Physician Specialty	Number	Percent	Number	Percent	Number	Percent	Number	Percent
All	575,745	100.0	16,247	100.0	360,704	100.0	2,946	100.0
General practice	191,744	33.3	7,782	47.9	113,673	31.5	1,423	48.3
Internal medicine	69,481	12.1	5,288	32.5	24,742	6.9	892	30.3
Ophthalmology	30,810	5.4	591	3.6	14,351	3.8	183	6.2
Cardiovascular	6,154	1.1	355	2.2	1,374	0.4	49	1.7
General surgery	28,315	4.9	353	2.2	15,195	4.2	100	3.4
Other surgery	45,994	8.0	342	2.1	25,446	7.1	11	0.4
Ob/Gyn	54,928	9.5	278	1.7	48,576	13.5	77	2.6
All other	148,319	25.8	1,257	7.7	117,345	32.5	212	7.2
(Pediatrics)	(64,223)	(11.2)						

	45-64				65+			
	All Visits		DM Visits		All Visits		DM Visits	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
All	129,805	100.0	6,834	100.0	85,236	100.0	6,466	100.0
General practice	46,868	36.1	3,092	45.1	31,203	36.5	3,267	50.4
Internal medicine	25,274	19.5	2,385	34.8	19,465	22.8	2,010	31.1
Ophthalmology	7,905	6.1	296	4.3	8,553	10.0	112	1.7
Cardiovascular	2,492	1.9	132	1.9	2,287	2.7	174	2.7
General surgery	8,485	6.5	136	2.0	4,635	5.4	108	1.7
Other surgery	13,730	10.6	157	2.3	6,818	8.0	173	2.7
Ob/Gyn	5,115	3.9	27	0.4	1,237	1.4	175	2.7
All other	19,935	15.4	609	8.9	11,037	12.9	437	6.8

*Includes all visits in which diabetes was listed on the physician-visit record form.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1980 National Ambulatory Medical Care Survey, National Center for Health Statistics.

treatment of diabetes, was about 50 percent higher than the proportion made to general practitioners among all visits in 1980. Only about 4 percent of visits for diabetes to office-based physicians were made to physicians whose specialty was diabetes or endocrinology, although 33 percent of visits for diabetes were made to internists whose specialty training often includes endocrinology. Some age-specific detail on patient visits to general practitioners and internists in the 1980 NAMCS are presented in Table 9. Among 6,074 diabetics diagnosed at age 30 years or older in an 11-county area of southern Wisconsin, 51 percent received their primary care from internists, 35 percent from general practitioners, and 14 percent from family practitioners (Klein et al. 1984).

TABLE 9. *Office-based visits involving diabetes to general practitioners (GPs) and internists, United States, 1980**

Patient's Age (Years)	Number of DM Visits to GPs (Thousands)	Percent of All Visits to GPs	Number of DM Visits to Internists (Thousands)	Percent of All Visits to Internists
All	7,782	4.06	5,288	7.61
0-24	678	1.11	384	0.21
25-34	213	0.71	202	2.79
35-44	532	2.37	306	4.03
45-54	1,308	5.80	843	7.95
55-64	1,785	7.35	1,541	10.52
65-74	2,367	10.53	1,399	10.29
75+	901	10.31	611	10.44

*Includes all visits in which diabetes was listed on the patient record form.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1980 National Ambulatory Medical Care Survey, National Center for Health Statistics.

Despite the seriousness of cardiovascular and vision conditions among diabetics, the proportion of visits to specialists in these two areas may be lower than expected. For patients ages 45 years and older, the proportion of visits to cardiovascular specialists were identical for diabetes visits and for all visits, and the proportion to ophthalmologists was lower for diabetes visits than for all visits to this specialty (Table 8). These data indicate that diabetics may not be obtaining the specialty care that their disease requires.

Certain characteristics recorded in the 1977 NAMCS for visits in which diabetes was the primary diagnosis are shown in Table 10. The 537,000 new diabetes patients corresponds to the estimated diabetes incidence of 570,000 new cases of diabetes in 1975 and 1978 (Drury and Harris 1984). Virtually all visits were by diabetics who had seen the physician before and were rescheduled for a return visit. Glucose measurement was the principal reason for 10 percent of visits, although lab tests were ordered in 69 percent. Prescribing of drugs and diet counseling were present in a significant proportion (62 and 37 percent). Blood pressure measurement was made in 67 percent, although vision was checked in less than 3 percent.

OTHER CONDITIONS PRESENT IN AMBULATORY VISITS FOR DIABETES

In the NAMCS, several conditions can be listed as being present during an office visit for diabetes, and these can provide some estimate of the multiple morbidity of diabetic patients. Hypertension and chronic ischemic heart disease were the most frequently mentioned conditions in 1977, with obesity also being listed as a diagnosis in a significant percent of visits (Table 11).

TABLE 10. *Selected characteristics of office visits for principal diagnosis of diabetes, United States, 1977*

Visit Characteristic	Number of Visits (Thousands)	Percent
All visits	11,023	100.0
Principal reason for visit		
Diabetes	4,903	44.5
Glucose level determination	1,111	10.1
General medical exam	921	8.4
Tiredness, weakness, eye exam, leg/foot/toe symptoms	683	6.2
Other	3,405	30.9
Prior visit status		
New patient	537	4.9
Old patient	10,486	95.2
New problem	646	5.9
Old problem	9,840	89.3
Disposition of visit		
No followup	117	1.1
Return at specified time	9,926	90.1
Return if needed	636	5.8
Telephone followup planned	365	3.3
Other*	511	4.6
Duration of visit (minutes)		
0**	364	3.3
1-5	1,079	9.8
6-10	3,436	31.2
11-15	3,203	29.1
16-30	2,580	23.4
31 or more	361	3.3
Diagnostic services		
None	208	1.9
Limited examination or history	5,839	53.0
General examination or history	2,493	22.6
Clinical lab test	7,635	69.3
X-ray	379	3.4
Electrocardiogram	528	4.8
Vision test	312	2.8
Blood pressure check	7,382	67.0
Other	569	5.2
Therapeutic services		
None	1,464	13.3
Drugs (prescription or nonprescription)	6,869	62.3
Diet counseling	4,125	37.4
Medical counseling	3,539	32.1
Other	814	7.4

*Includes referred to other physician, returned to referring physician, and admit to hospital.

**Represents visits in which there was no face-to-face contact between the patient and the physician.

SOURCE: Ezzati, T. Office visits for diabetes mellitus, National Ambulatory Medical Care Survey, U.S., 1977. NCHS Advance Data, No. 57, January 25, 1980.

TABLE 11. *Number (thousands) of physician office visits with diabetes recorded as first-, second-, or third-listed diagnosis, by selected diagnosis associated with diabetes in ambulatory medical care practices, United States, 1977*

Selected Diagnoses Associated with Diabetes	ICDA-8 Code	Total Number with Specified Associated dx	Total Percent with Specified Associated dx*	Number with Diabetes as the First-Listed Diagnosis (Total = 11,022.9)		Number with Diabetes as the Second-Listed Diagnosis (Total = 6,096.7)		Number with Diabetes as the Third-Listed Diagnosis (Total = 1,717.9)	
				Specified dx Second-Listed	Specified dx Third-Listed	Specified dx First-Listed	Specified dx Third-Listed	Specified dx First-Listed	Specified dx Second-Listed
Obesity not specified as of endocrine origin	277	1,146.7	6.1	506.5	189.7	41.3	194.9	20.1	194.2
Neuroses	300	328.9	1.8	143.5	41.3	98.5	37.6	8.0	-
Other and unspecified forms of neuralgia and neuritis	355	107.9	0.6	24.2	-	72.5	-	11.2	-
Other diseases of retina and optic nerve	377	102.8	0.6	13.3	7.5	49.5	10.9	3.8	17.9
Essential benign hypertension	401	3,719.7	19.8	1,697.0	197.0	1,062.2	400.6	167.4	195.6
Myocardial insufficiency:									
Hypertensive heart disease	402	100.1	0.5	13.3	-	25.6	-	44.4	16.8
Chronic ischemic heart disease	412	2,081.5	11.0	666.9	149.4	563.0	245.7	342.5	114.0
Angina pectoris	413	324.1	1.8	30.2	40.2	50.4	33.9	21.7	147.8
Symptomatic heart disease	427	738.2	4.0	272.1	56.2	108.8	140.1	19.1	141.9
Other myocardial insufficiency	428	36.0	0.2	9.7	-	-	-	6.6	19.7
Transient cerebral ischemia	435	19.0	0.1	-	-	-	-	19.0	-
Acute but ill-defined cerebrovascular disease	436	150.6	0.8	72.4	-	73.0	-	5.3	-
Arteriosclerosis	440	394.2	3.0	53.0	167.6	47.1	103.2	19.8	3.4
Arterial embolism and thrombosis	444	44.9	0.2	-	-	-	-	-	44.9
Other diseases of circulatory system	458	113.0	0.6	48.5	22.9	9.2	13.2	-	19.2
Other cellulitis and abscess	682	95.4	0.5	9.3	5.0	25.7	8.1	30.5	16.8
Psoriasis and similar disorders	696	19.0	0.1	-	-	-	-	-	19.0
Chronic ulcer of skin	707	153.3	0.8	23.8	20.1	112.8	-	17.6	-
Rheumatoid arthritis and allied conditions	712	108.0	0.6	19.5	10.1	38.8	-	18.8	20.8
Osteoarthritis and allied conditions	713	570.1	3.0	82.3	96.7	149.4	74.2	89.7	77.8
Arthritis, unspecified	715	361.1	2.0	99.9	27.6	180.5	31.5	3.3	18.2
Nervousness and debility	790	182.0	1.0	50.9	25.6	57.1	4.9	20.6	22.8
Medical and surgical aftercare	Y10	414.4	2.2	122.3	33.0	159.5	29.2	42.4	28.0

*As percent of total number of visits with diabetes listed on the patient record form (N=18.8 million).

SOURCE: Sayetta, RB, and RS Murphy. Summary of current diabetes-related data from the National Center for Health Statistics. Diabetes Care 2:105-19, 1979. (1977 National Ambulatory Medical Care Survey)

IMPACT OF DIABETES ON THE AMBULATORY MEDICAL CARE SYSTEM

In 1981, diabetes was the seventh most common cause of visits to office-based physicians, although three of the diagnoses that were more common were not diseases (Table 12). Diabetes was the third leading cause of visits to internists in 1975, exceeded only by visits for hypertension and ischemic heart disease (Cypress 1978). It was the fourth leading cause of visits to general practitioners, exceeded only by visits for a general medical exam, hypertension, and upper respiratory infection (Cypress 1977). For patients ages 55 years and older, diabetes was involved in virtually 10 percent of all visits to internists and general practitioners (Table 9).

TABLE 12. *Percent of visits to office-based physicians for the 20 most common principal diagnoses, United States, 1981*

Rank	Diagnosis	ICD-9-CM Code	Percent
1	Hypertension	401	4.9
2	Normal pregnancy	V22	4.3
3	Infant/child exams	V20	3.2
4	Acute upper respiratory infections	465	2.5
5	General medical exam	V70	2.4
6	Otitis media	382	2.2
7	Diabetes mellitus	250	1.8
8	Special exams	V72	1.8
9	Followup exams	V67	1.7
10	Acne	706	1.7
11	Neuroses	300	1.6
12	Sore throat	462	1.4
13	Allergic rhinitis	477	1.4
14	Eye exam	367	1.4
15	Bronchitis	490	1.2
16	Chronic ischemic heart disease	414	1.1
17	Osteoarthritis	715	1.0
18	Dermatitis/eczema	692	0.9
19	Tonsillitis	463	0.9
20	Asthma	493	0.9
-	All other diagnoses	-	61.6

SOURCE: Lawrence, L, and T McLemore. 1981 Summary, National Ambulatory Medical Care Survey. NCHS Advance Data, No. 88, March 16, 1983.

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APPENDIX A. *Selected physician characteristics in office visits for principal diagnosis of diabetes, United States, 1977*

Physician Characteristic	Number of Visits (Thousands)	Percent
All	11,023	100.0
Physician specialty		
General and family practice	5,891	53.4
Internal medicine	3,075	27.9
Other medical specialties	1,125	10.2
Surgical specialties	876	8.0
Other specialties	56	0.5
Type of practice		
Solo	7,737	70.2
Other*	3,286	29.8
Location of practice		
Metropolitan**	8,469	76.8
Nonmetropolitan	2,554	23.2

*Includes partnership and group practices.

**Located within the standard metropolitan statistical areas (SMSA).

SOURCE: Ezzati, T. Office Visits for Diabetes Mellitus, National Ambulatory Medical Care Survey, U.S., 1977. NCHS Advance Data, No. 57, January 25, 1980.

APPENDIX B. *Diabetes in the office-based practices of physicians: Number and percent of visits involving diabetes, by medical specialty, United States, 1980*

Medical Specialty	Thousands of Visits*	Percent of All Visits to the M.D. Specialist
All specialties	16,247	2.82
General practice	7,782	4.06
Internal medicine	5,288	7.61
Ophthalmology	591	1.92
Cardiovascular	355	5.77
General surgery	354	1.25
Other surgery	342	0.74
Ob/Gyn	278	0.51
All other	1,257	0.85

*Includes all visits in which diabetes was listed on the patient record form.

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1980 National Ambulatory Medical Care Survey, National Center for Health Statistics.

APPENDIX C. *Number of prescriptions (thousands) for hypoglycemic drugs prescribed by physicians during office visits for diabetes,* United States, 1980 and 1981*

Drug	1980	1981
Insulin	5,248	5,314
Diabinese (chlorpropamide)	3,204	2,876
Orinase (tolbutamide)	1,352	1,146
Tolinase (tolazamide)	870	1,188
Dymelor (acetohexamide)	-	377

*Approximately 16 million visits for diabetes to physicians' offices occurred in each year.

SOURCE: Koch, H. Drugs most frequently used in office-based practice. National Center for Health Statistics, Vital and Health Statistics Advance Data, No. 78, May 12, 1982; personal communication for 1981 data.

CHAPTER XXVI. HOSPITAL UTILIZATION FOR DIABETES

Pomeroy Sinnock, Ph.D.

SUMMARY

In 1983 there were 2.8 million hospitalizations that were recorded to involve diabetes, accounting for 7.2 percent of all hospital discharges in the United States. The hospitalization rate for diabetics was 2.4 times greater than that for nondiabetics, and among children it was 5.3 times greater. The hospitalization rates for diabetic children and young and middle-aged adults were about equal (33 per 100 diabetics per year) but the rate was 50 percent greater for diabetics aged 65 years and older (50 per 100 diabetics per year). A large proportion of diabetic admissions were for control of diabetes. The length of hospital stay for diabetes as the primary diagnosis was 9.5 days, which was 2.3 days longer than for nondiabetic hospitalizations. The average cost of hospital care for diabetics admitted to hospitals in 1977 was $3,784 per person, which was 56 percent greater than the cost of a nondiabetic hospitalization. The total cost for hospital care of diabetics was estimated at between $2.2 billion and $6.5 billion in 1980.

THE NATIONAL HOSPITAL DISCHARGE SURVEY

Since 1965, the National Center for Health Statistics has collected hospital utilization data through the National Hospital Discharge Survey (HDS) (Simmons 1970, Haupt 1982). These surveys provide the most valid national estimates of hospitalization for diabetes. Information collected in the surveys includes patient characteristics, diagnoses, surgical procedures, and length of stay for a sample of hospital discharges. Diabetes hospitalizations (discharges) are identified when diabetes is selected as the principal reason for hospitalization (primary diagnosis) and when diabetes is an "other-listed" diagnosis (secondary or tertiary reason for the hospitalization). For each hospital discharge, a primary diagnosis must be selected in order to tabulate national statistics; however, the importance of other-listed diagnoses should not be underestimated. Information from the HDS is very accurate for demographic and other nonmedical entities (Institute of Medicine 1980). However, although data on race are collected, they are not statistically reliable, and rates by race cannot be accurately

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determined. The reliability of medical diagnoses is less accurate than demographic data; when diabetes hospital abstracts were examined, there was 72 percent agreement with HDS (Institute of Medicine 1980).

Diabetes is identified in the International Classification of Diseases Annotated (ICDA) system by code number 250. Since 1979 a "fourth digit" has been used to distinguish the various complications of diabetes. For example, for hospital discharges the code 250.4 signifies diabetes with kidney complications. Diabetes also has a fifth digit available to distinguish between juvenile onset diabetes and adult (or unspecified) onset diabetes. The uniform application of the fifth digit is questionable, however, and these data will not be presented here.

FREQUENCY OF HOSPITALIZATIONS FOR DIABETES

Among persons ages 20-74 years, 25 percent of diabetics and 15 percent of nondiabetics had one or more hospital stays during the previous year when surveyed in 1976-80 (Harris 1984). In 1983, there were 2.8 million hospitalizations that were recorded as involving diabetes, accounting for 7.2 percent of all hospitalizations in the United States (Table 1). The percent increased with age, reaching 12 percent of all hospitalizations represented by diabetics age 65 years and older (Table 2). Most hospitalizations of persons with diabetes were coded to medical conditions other than diabetes; there were 3.1 times more discharges having diabetes listed as a secondary or tertiary diagnosis than with diabetes as the first-listed diagnosis (Table 1), and, among all diabetes discharges, only 24 percent had diabetes as the first-listed diagnosis. Thus national statistics that consider only first-listed diagnoses seriously underestimate the extent of hospitalizations for diabetes. The percent with diabetes as first-listed diagnosis declined with increasing age, from 80 percent in the 0-14 age group to 19 percent in the 65+ age group (Table 2). Thus if a young diabetic was hospitalized, it was four times more likely to be coded as a primary diagnosis of diabetes than if an older diabetic was hospitalized.

TABLE 1. *Number of hospitalizations for diabetes and percent of all hospitalizations, United States, 1971-83*

Year	Diabetes as Primary Diagnosis (Thousands)	Diabetes as Other-Listed Diagnosis (Thousands)	Total Diabetes (Thousands)	Total U.S. Hospitalizations (Thousands)	Diabetes as Percent of Total
1971	430	932	1,362	29,459	4.6
1972	488	1,033	1,521	31,627	4.8
1973	501	1,163	1,664	32,125	5.2
1974	521	1,293	1,814	33,018	5.5
1975	533	1,360	1,893	34,043	5.6
1976	551	1,393	1,944	34,372	5.7
1977	574	1,440	2,014	35,902	5.6
1978	584	1,476	2,060	35,616	5.8
1979	600	1,536	2,136	36,747	5.8
1980	638	1,633	2,271	37,832	6.0
1981	647	1,749	2,396	38,544	6.2
1982	655	1,908	2,563	38,593	6.6
1983	675	2,100	2,775	38,783	7.2

SOURCE: National Hospital Discharge Surveys, National Center for Health Statistics.

National hospitalization rates are generally presented as number of hospitalizations per 10,000 United States population. This rate for diabetes increased with increasing age from 5.5 per 10,000 population in the 0-14 age group to 488 per 10,000 population in the over 65 age group (Table 2). There are regional differences in total diabetes discharge rates: diabetes accounted for 6.7 percent of discharges in the Northeast, 5.4 percent in the North Central, 5.2 percent in the South, and 4.4 percent in the West in 1976-78.

TABLE 2. *Annual number and rate per 10,000 population of hospitalizations with diabetes as a primary or other-listed diagnosis, United States, 1981-82*

	Age (Years)				
	0-14	15-44	45-64	65+	All Ages
Primary diagnosis (thousands)	22	143	240	234	651
Other-listed diagnosis (thousands)	6	200	608	1,012	1,829
Total hospitalizations (thousands)	28	343	848	1,246	2,480
Percent as primary diagnosis	80%	42%	28%	19%	26%
Total number per 10,000 U.S. population	5.5	32.6	190.6	487.9	109.5
Percent of all U.S. hospitalizations	0.8%	2.2%	9.8%	12.0%	6.4%

SOURCE: National Hospital Discharge Surveys, National Center for Health Statistics.

DIABETES HOSPITALIZATION RATES IN THE DIABETIC POPULATION

Analyses having diabetics as the reference population rather than the total United States population present a different picture from that when rates are calculated per 10,000 United States population. In 1976-78, total diabetes discharge rates (first-listed plus other-listed) per 10,000 diabetics were nearly equal for ages less than 65 years but were substantially higher in the 65+ group (Table 3, Figure 1). The rates for males and females were virtually identical and the disparity among regions was less. The hospitalization rate among diabetics was 2.4 times greater than the total United States rate, and among diabetic children it was 5.3 times greater.

TIME TRENDS

Hospital discharge rates for diabetes as the primary reason for hospitalization have increased from 19.7 discharges per 10,000 population of all ages in 1968 to 29.8 in 1983 (Table 4). When these rates are age-adjusted to the 1970 United States population composition, discharge rates for diabetes have increased 38 percent over this time period. A similar increase has occurred in rates of hospitalization for diabetes as an other-listed diagnosis (Table 4). Although the total hospitalization rate in the United States has also risen during this time, diabetes now accounts for a greater proportion of hospitalizations. The percent of all hospitalizations in the United States in which diabetes was a diagnosis has increased from 4.6 percent in 1971 to 7.2 percent in 1983 (Table 1). Age-specific rates have increased for all age groups. In all regions, rates increased between 1968 and 1980, although the West showed the least increase—9 percent, compared to 57 percent, 43 percent, and 66 percent for the South, North Central, and Northeast, respectively.

TABLE 3. *Rates of hospitalization for all diagnoses and rates with diabetes as a primary or other-listed diagnosis per 10,000 diabetics, United States, 1976-78*

	Rate Per 10,000 Persons, All Diagnoses*	Rate For Diabetes Per 10,000 Diabetics			Total Diabetes ÷ All Diagnoses
		Primary Diagnosis	Other-Listed Diagnosis	Total Diabetics	
Age 0-14	688	2,656	944	3,650	5.3
15-44	1,551	1,494	1,672	3,166	2.0
45-64	1,931	940	2,362	3,302	1.7
65+	3,819	1,084	3,982	5,066	1.3
All	1,665	1,116	2,822	3,938	2.4
All males		1,077	2,880*	3,957	
All females		1,203	2,816*	4,019	
Northeast		1,234	3,353	4,587	
North Central		1,329	3,213	4,542	
South		994	2,308	3,302	
West		870	2,531	3,401	

*Data for 1978 only.

SOURCES: Estimates of the United States diabetes population were made from the National Health Interview Surveys; estimates of diabetes hospitalizations were derived from the National Hospital Discharge Surveys, National Center for Health Statistics.

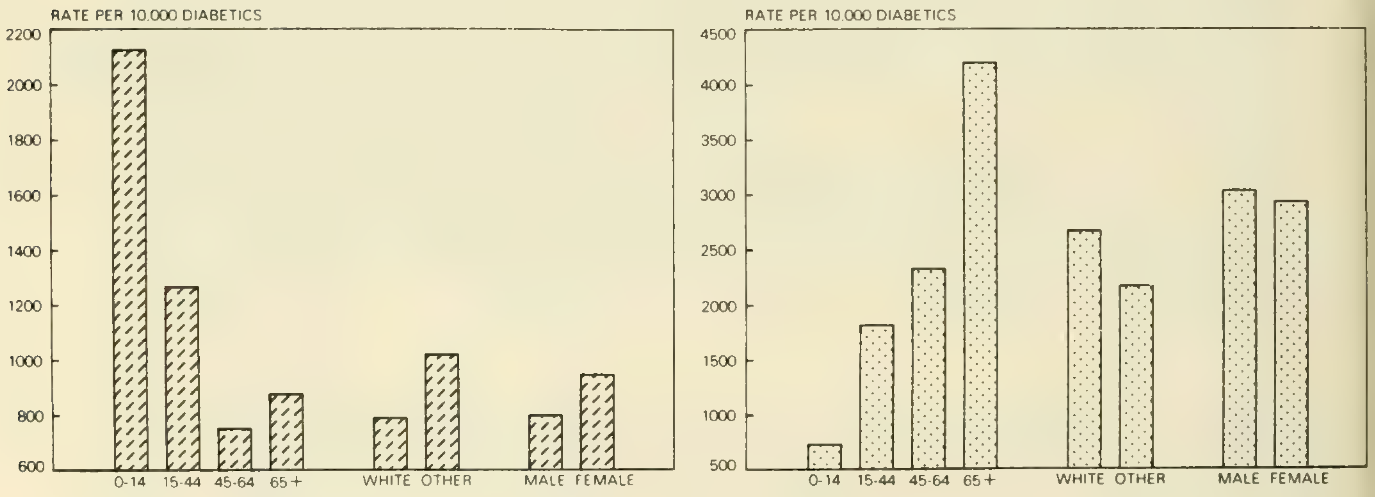

FIGURE 1. *Estimated rates of hospitalization for diabetes as the primary (left figure) and the secondary (right figure) diagnosis per 10,000 diabetics, United States, 1978*

SOURCE: Sinnock, P, et al. Assessment of diabetes morbidity/mortality data in diabetes control program states. Proc. 5th Diabetes Control Conference, May 1982, Lexington, Kentucky.

HOSPITALIZATION RATES FOR DIABETIC COMPLICATIONS

The majority of hospital discharges for diabetes do not mention any specific diabetic complication (Tables 5 and 6). Whether this is because complications do not occur or because they are simply not listed on the hospital record is unknown. In a study in eight Michigan communities in 1981-82, about half of the 428 diabetics studied were admitted to the hospital. The majority were for diabetic control (46 percent); other diabetic complications constituted the remainder of hospital admissions (Table 7).

TABLE 4. *Number of hospital discharges with diabetes as the primary or other-listed diagnosis per 10,000 United States population, United States, 1968-83*

Year	Primary Diagnosis	Other-Listed Diagnosis	Total
1968	19.7	41.9	61.6
1971	21.3	46.1	67.4
1972	23.9	50.6	74.5
1973	24.4	56.5	80.9
1974	25.1	62.3	87.4
1975	25.5	65.0	90.5
1976	26.2	66.1	92.3
1977	27.1	67.9	95.0
1978	27.3	69.0	96.3
1979	27.8	71.2	99.0
1980	28.1	73.3	101.4
1981	28.6	77.2	105.8
1982	28.9	84.2	113.2
1983	29.8	92.7	122.5

SOURCE: National Hospital Discharge Surveys, National Center for Health Statistics.

TABLE 5. *Number* (thousands) and percent distribution of hospital discharges with diabetes complications as the primary or other-listed diagnosis, United States, 1981 and 1982*

		Age (Years)									
		0-14		15-44		45-64		65+		All Ages	
ICD Number	Complication	No.	%	No.	%	No.	%	No.	%	No.	%
250.0	No complications	36	66.7	422	61.5	1,273	75.1	2,040	81.9	3,771	76.0
250.1	Ketoacidosis	18	33.3	67	9.8	39	2.3	20	0.8	114	2.9
250.2	Hyperosmolar coma	-	-	-	-	-	-	-	-	13	0.3
250.3	Other coma	-	-	7	1.0	-	-	-	-	17	0.3
250.4	Kidney	-	-	27	3.9	44	2.6	33	1.3	104	2.1
250.5	Eye	-	-	43	6.3	45	2.7	35	1.4	124	2.5
250.6	Neurologic	-	-	39	5.7	89	5.3	85	3.4	213	4.3
250.7	Peripheral circulatory	-	-	-	-	23	1.4	49	2.0	74	1.5
250.8	Other specified	-	-	23	3.4	53	3.1	87	3.5	164	3.3
250.9	Other unspecified	-	-	58	8.4	128	7.6	143	5.7	335	6.8
250	All	54	100.0	686	100.0	1,694	100.0	2,492	100.0	4,959	100.0

*Numbers are the sum of the two years.

SOURCE: National Hospital Discharge Surveys, National Center for Health Statistics.

Among young insulin-using patients in Rhode Island in 1979-83, poor diabetic control was also a major reason for hospitalization (Table 8). There were regional and state differences in the distribution of discharges for diabetes complications as the primary diagnosis (Table 6), but the reasons for these variations between states is unknown.

TABLE 6. *Percent distribution of hospital discharges with diabetes as the primary diagnosis, by complication and State, 1979-81*

ICD Number	Complication	Pa.*	N.J.*	R.I.*	R.I.*	United States**		
		1980	1979	1979	1980	1979	1980	1981
250.0	No complications	58.6	40.8	48.6	34.2	60.6	56.4	55.1
250.1	Ketoacidosis	10.8	13.1	12.2	13.2	8.7	9.2	9.8
250.2	Hyperosmolar coma	1.2	1.2	.9	1.3	.6	.4	.6
250.3	Other coma	.4	.8	.5	1.3	1.6	.6	.6
250.4	Kidney	1.7	2.5	1.6	1.9	1.8	1.8	2.1
250.5	Eye	5.1	2.7	2.3	1.8	2.7	2.0	2.6
250.6	Neurologic	6.0	4.6	9.5	6.0	5.2	5.5	6.1
250.7	Peripheral circulatory	3.4	6.1	6.0	3.9	3.5	4.0	2.8
250.8	Other specified	1.1	4.4	1.9	1.9	3.2	4.3	4.0
250.9	Other unspecified	11.5	23.6	16.6	34.5	12.1	15.7	16.3

*Pa., N.J., and R.I. data are from the Diabetes Control Programs of these states.
**National Hospital Discharge Surveys, National Center for Health Statistics.

TABLE 7. *Hospital admissions among diabetics in eight Michigan communities, 1981-82**

	Number	Percent
Number of diabetics	428	100
Number admitted to hospital	237	55
Causes for admission		
Diabetic control	109	46
Ketoacidosis	13	5
Foot problems	10	4
Heart trouble	28	12
Kidney trouble	15	6
Visual problems	16	7
Other	46	19

*Based on the private practice of 61 physicians, with seven diabetics selected from each practice.

SOURCE: Hiss, RG. Analysis of Community Diabetes Care. Unpublished paper presented at the Diabetes Research and Training Center meeting, June 1983, San Antonio.

LENGTH OF HOSPITAL STAY

The average length of hospital stay has been decreasing in the United States for a number of years, and it has also decreased for discharges with a first-listed diagnosis of diabetes (Table 9). However, the length of stay for diabetic discharges has consistently been greater than for all discharges. Adjusting for age, persons hospitalized with diabetes as the first-listed diagnosis had approximately a 1.7-day greater length of stay than nondiabetics did.

Data on length of stay for other-listed diabetes diagnoses is not available from the Hospital Discharge Survey but can be estimated from selected State data from the Centers for Disease Control (CDC) Diabetes Control Program. In these, discharges with diabetes as an other-listed diagnosis in 1975-78 had an average length of stay that was 1.6 days longer than for diabetes as a first-listed diagnosis.

TABLE 8. *Primary precipitants of 1,123 hospitalizations among insulin-using diabetic patients, Rhode Island, 1979-83*

Cause of Hospitalization	Percent
Poor diabetic control	32.4
Infection	13.9
Surgery	10.4
Diabetic complications	6.0
Other	37.3

SOURCE: Fishbein, HA, GA Faich, and SE Ellis. Incidence and hospitalization patterns of IDDM. Diabetes Care 5:630-33, 1982; and Rhode Island Diabetes Control Program FY 1984 Report.

TABLE 9. *Length of stay (days) for diabetes hospitalizations and all hospitalizations, United States, 1971-83*

Year	Diabetes (Primary Diagnosis)	All U.S. Hospitalizations	Excess Days for Diabetes
1971	11.3	7.8	3.5
1972	10.7	7.7	3.0
1973	11.1	7.8	3.3
1974	10.9	7.7	3.2
1975	10.2	7.7	2.5
1976	10.4	7.6	2.8
1977	9.8	7.3	2.5
1978	9.7	7.4	2.3
1979	10.1	7.2	2.9
1980	10.5	7.3	3.2
1981	9.7	7.2	2.5
1982	9.5	7.1	2.4
1983	9.5	6.9	2.6

SOURCE: National Hospital Discharge Surveys, National Center for Health Statistics.

During 1965-80, females had a longer length of stay than males (11.2 days vs. 10.4 days), and whites had a shorter length of stay than nonwhites, (10.6 days vs. 12.5 days). The average length of stay for the 0-14, 15-44, 45-64, and 65+ age groups was 7.3, 7.8, 10.3 and 12.6, respectively. There were regional differences in average length of stay per discharge; 1965-80 averages for the Northeast, North Central, South, and West were 13.0, 10.8, 9.9, and 8.7 days, respectively. Part of this variation may be due to the different age structure among the four regions.

SURGICAL PROCEDURES

Surgical procedure data including up to four procedures per discharge are collected through the HDS. Among all procedures with diabetes as the primary diagnosis, the most frequent were operations on the cardiovascular system and digestive system, and miscellaneous diagnostic and therapeutic procedures (Table 10). Operations involving the cardiovascular system occurred in a greater percent of diabetes discharges than in the total population (11.3 percent vs. 4.3 percent) The frequency of miscellaneous procedures was nearly twice as great in diabetes discharges as in total discharges. Some of these differences result from the fact that diabetics are much older than the general United States population.

In 1980, there were an estimated 471 kidney transplants in diabetics (procedure code 55.6), 3,554 vitrectomies (procedure code 14.73-14.74), and 40,381 amputations of the lower limbs (procedure codes 84.10-84.19).

TABLE 10. *Percent distribution of surgical procedures with diabetes or all conditions as the primary diagnosis, United States, 1980*

Site of Surgical Procedure	Code Number	Diabetes	All Operations
Nervous system	01-05	2.4	2.3
Endocrine system	06-07	0.3	0.4
Eye	08-16	5.5	3.3
Ear	18-20	0.2	1.3
Nose, mouth, and pharynx	21-29	1.3	5.1
Respiratory system	30-34	3.5	2.8
Cardiovascular system	35-39	11.3	4.3
Hemic and lymphatic system	40-41	1.3	1.0
Digestive system	42-54	16.9	16.9
Urinary system	55-59	8.4	6.1
Male genital organs	60-64	3.6	2.5
Female genital organs	65-71	4.8	13.6
Obstetrical procedures	72-75	1.7	11.5
Musculoskeletal system	76-84	8.5	10.2
Integumentary system	85-86	6.9	6.0
Miscellaneous diagnostic and therapeutic procedures	87-99	23.3	12.5

SOURCE: National Hospital Discharge Surveys, National Center for Health Statistics.

MORTALITY RATES AMONG HOSPITALIZED DIABETICS

The mortality rate among hospitalized diabetics in 1979-81 was 1.7 percent for diabetes as a first-listed diagnosis, although the highest rates of 17.4 percent and 14.6 percent occurred for hyperosmolar coma (250.2) and diabetic coma (250.3) (Table 11). For all hospitalizations in the United States in 1981, death occurred in 2.5 percent (Pokras 1983).

TABLE 11. *Deaths per 100 hospital discharges for all diagnoses and for a diabetes complication as the primary diagnosis, United States, 1979-81*

ICD Number	Primary Diagnosis	Deaths Per 100 Hospitalizations
All	All diagnoses	2.5
250	All diabetes diagnoses	1.7
250.0	No complications listed	1.2
250.1	Ketoacidosis	2.8
250.2	Hyperosmolar coma	17.4
250.3	Other coma	14.6
250.4	Kidney	5.3
250.5	Eye	0.9
250.6	Neurologic	0.4
250.7	Peripheral circulatory	5.3
250.8	Other specified complication	1.4
250.9	Other unspecified complication	1.4

SOURCE: U.S. National Hospital Discharge Surveys, National Center for Health Statistics.

READMISSION RATES FOR DIABETES

In Rhode Island in 1979-83, 887 insulin-using diabetics aged less than 30 years were hospitalized. Of 691 who were previously diagnosed diabetics, 203 (29 percent) were admitted more than once during this period; of the 196 newly diagnosed cases, 18 were readmitted to the hospital during 1979-83 (Fishbein 1984). A similar percent of young diabetics who were Medicaid recipients in Michigan were also readmitted to a hospital in 1977 (Table 12). The percent readmitted decreased with age.

TABLE 12. *Percent of 3,799 Michigan diabetic Medicaid recipients readmitted to a Michigan hospital, 1977*

Age (Years)	Percent Readmitted
0-14	28.9
15-34	28.8
35-44	20.2
45-64	20.6
65+	10.1

SOURCE: Office of Vital and Health Statistics, Michigan Department of Public Health, from data of the Michigan Medicaid Surveillance and Utilization Program.

COST OF HOSPITALIZATION FOR DIABETES

In the United States in 1977, 28 percent of diabetics experienced an expense for hospital care, compared with only 11 percent of nondiabetics (Table 13). The total hospital expense for diabetics was $4.83 billion, representing 8.5 percent of all hospital expenses in the United States. The average expense per diabetic hospitalized was 57 percent higher than for nondiabetic hospitalizations.

Based on the estimates of average length of hospital stay in 1980 of 10.5 days for a first-listed diagnosis of diabetes and 12.1 days for an other-listed diagnosis of diabetes (Table 9), 2.27 million hospitalizations for diabetes in that year (Table 1), and an average cost per hospital day of $245 (HIAA 1983), it can be calculated that hospitalizations for diabetes in 1980 cost a total of $6.5 billion. Other estimates that include only hospitalizations directly attributable to diabetes have been as low as $2.2 billion (Hodgson and Kopstein 1983).

TABLE 13. *Expenses for hospital care of diabetics, United States, 1977*

	Diabetics			Nondiabetics		
Age (Years)	Percent of Persons with Expense	Average Expense (Dollars)	Total Expense (Billions of Dollars)	Percent of Persons with Expense	Average Expense (Dollars)	Total Expense (Billions of Dollars)
All	27.8	3,784	4.83	11.3	2,417	56.8
<45	24.8	2,617	0.46	9.5	1,691	23.3
45-64	24.5	3,551	1.66	13.5	3,078	17.4
65+	31.4	4,277	2.71	20.1	3,959	16.1

SOURCE: Meyers, S, MI Harris, T Drury, and P Entmacher. 1977 National Medical Care Expenditure Survey, National Center for Health Services Research.

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APPENDIX A. *Rate of hospital discharges with certain primary diagnoses and average length of stay, United States, 1979*

Diagnostic Categories	Rate of Discharges Per 1,000 Population*			Average Length of Stay (Days)		
	Total	Male	Female	Total	Male	Female
All conditions	170.2	141.2	197.3	7.2	7.7	6.9
All ischemic heart disease	8.1	9.7	6.5	9.6	9.2	10.2
Malignant neoplasms	8.1	8.1	8.1	12.3	12.3	12.4
Benign neoplasms, carcinoma in-situ, and neoplasms of uncertain behavior	3.0	1.4	4.6	6.2	6.1	6.2
Fractures, all sites	5.5	5.8	5.1	10.5	8.8	12.3
Diseases of the urinary system	5.5	5.4	5.7	6.8	7.0	6.6
Pneumonia, all forms	3.5	3.9	3.2	8.0	7.8	8.2
Chronic disease of tonsils and adenoids	2.3	2.1	2.5	2.0	1.8	2.1
Cerebrovascular disease	3.5	3.2	3.7	12.4	12.1	12.6
Diabetes mellitus	2.8	2.2	3.3	10.1	9.4	10.6
Inguinal hernia	2.2	4.1	0.4	4.9	4.9	5.2
Cholelithiasis	2.1	1.2	2.9	9.8	10.6	9.5
Appendicitis	1.3	1.5	1.1	5.8	5.6	6.1
Childbirth	-	-	7.3*	-	-	4.2
With complications	-	-	3.7*	-	-	5.7
Without complications	-	-	3.5*	-	-	3.0

*Rate of discharge for childbirth is based on population of women age 15-44.

SOURCE: 1979 U.S. Hospital Discharge Survey, National Center for Health Statistics.

APPENDIX B. *Percent of diabetics alive in 1976 who were hospitalized when diagnosed, by year of diagnosis*

Year of Diagnosis	Percent Hospitalized
1920-39	27
1940-59	29
1960-69	30
1970-76	31

SOURCE: Harris, MI, National Diabetes Data Group, from data of the 1976 Health Interview Survey, National Center for Health Statistics.

CHAPTER XXVII. NURSING HOME CARE FOR DIABETICS

Joan F. Van Nostrand, M.P.A.

SUMMARY

Data from the 1977 National Nursing Home Survey provide a profile of the demography, health status, and health care of diabetics in nursing homes. One in every seven nursing home residents (189,600 persons) was diabetic, comprising 15 percent of the nursing home population. For persons 45 years and older, the rates of diabetes in nursing home residents were twice those found in the general population.

About 75 percent of diabetics were 75 years of age and older, 75 percent were female, and 90 percent were white. Only 10 percent were married. Most had been admitted to a nursing home from another health facility. Virtually all had some chronic medical condition besides diabetes; about two-thirds had three or more other chronic conditions. Of every 10 diabetic residents, 7 were impaired in mobility and 4 were incontinent.

Seventy percent had been seen by a physician within the previous month and 42 percent received intensive nursing care. About 81 percent received a diabetic diet. Two-thirds were taking insulin or oral hypoglycemic agents, but many other medications were in the treatment regimen of diabetic patients.

The primary sources of payment were Medicaid (56 percent) and own income or family support (33 percent). The median duration of stay was 85 days. About 25 percent were dead on discharge, and 65 percent of those discharged alive entered some other health facility, where 10 percent died.

In comparison to nondiabetic nursing home residents, the health of diabetics was generally poorer. A greater proportion required assistance in walking or were confined to bed or chair. Diabetics had higher rates of heart trouble, hypertension, and missing arms, legs, and extremities. Given the coexistence of these conditions, it is not surprising that more diabetics received diuretics, cardiac glycosides, and antihypertensive drugs. The health services received further emphasized the poorer health status of diabetics. A greater proportion received nursing care, special diets, orders

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for laboratory tests, and medications. Diabetics appeared to be in poorer health when discharged, as a greater percent were discharged to general hospitals to receive more intensive services than the nursing home could provide.

SOURCES OF DATA

The data in this chapter are taken from the National Nursing Home Survey conducted by the National Center for Health Statistics. Data are primarily from the 1977 survey which provides the most recent national data. In 1977, all 18,900 nursing homes in the coterminous United States were included in the scope of the survey regardless of the intensity of their service and their participation in the Medicare and Medicaid programs. Nursing homes providing skilled care, intermediate care, or domiciliary care were included, but places providing only room and board were not. Facilities for the mentally ill and the physically or mentally handicapped, and the 3,000 persons with diabetes as their primary diagnosis in these facilities, were also excluded from analysis (Bureau of the Census 1978). Data were collected from a nationally representative sample of nursing homes. Within each home a sample of five current residents was selected. The nurse most familiar with the care provided to the resident was interviewed. The nurse referred to the resident's medical record and supplemented that information with personal knowledge when appropriate. Reports that describe the procedures for the 1977 and earlier surveys and present data for all residents are available (Van Nostrand et al. 1979, Hing 1981, Nelson 1967, Sirrocco 1973, Ingram 1977).

The term diabetes in this chapter refers to "diagnosed diabetes as recorded in the medical records of nursing home residents." No information was collected on age at onset of diabetes, but since most nursing home patients were elderly, it is likely that the majority were of the noninsulin-dependent type. Tests of statistical inference (Hing 1981) were conducted to confirm that differences between two statistics were significant, (i.e., not due to the effects of sampling). If significant differences were found, the text describes the estimates as "greater," "higher," or "lower." If significant differences were not found, the text either describes the estimates as "the same," "similar," "no difference," or makes no comment concerning a difference.

DEMOGRAPHIC PROFILE

In 1977, there were about 189,600 diagnosed diabetics in nursing homes in the United States, comprising nearly 15 percent of the Nation's nursing home population (Table 1). The rate of diabetics ages 45 and over in nursing homes was twice as high as the rate in the general population. This differential in rates was equally evident for each age group and for males as well as for females. It is an indicator of the importance of long-term institutional care in meeting the health care needs of middle-aged and elderly diabetics.

TABLE 1. *Prevalence of diabetes among persons ages 45 years and over in nursing homes and in the general population, United States, 1977 and 1979*

Sex and Age (Years)	Nursing Home Population (1977) Number	Nursing Home Population (1977) Percent	General Population (1979) Percent (N=4.32 million)
Both sexes			
45+	188,000	14.8	6.5
45-64	19,200	13.3	5.4
65+	168,800	15.0	8.4
65-74	38,200	18.1	8.0
75-84	75,600	16.3	10.0
85+	55,000	12.2	4.8
Male			
45+	46,900	13.1	6.2
45-64	8,100	12.8	5.4
65+	38,700	13.2	7.8
65-74	11,600	14.5	7.5
75-84	16,600	13.6	9.1
85+	10,500	11.5	6.3
Female			
45+	141,200	15.5	6.7
45-64	11,100	13.7	5.5
65+	130,100	15.6	8.8
65-74	26,600	20.3	8.4
75-84	59,000	17.2	10.6
85+	44,500	12.4	4.0

SOURCES: Divisions of Health Care and Health Interview Statistics, 1977 National Nursing Home Survey and 1979 National Health Interview Survey, National Center for Health Statistics.

The demographic profile of elderly nursing home residents with diagnosed diabetes did not differ significantly from that of nondiabetic residents. About 80 percent of both groups were age 75 and over. The majority were female (about 75 percent), widowed (about 70 percent), and white (about 90 percent) (Table 2). Marital status differed significantly between female and male residents with diagnosed diabetes. Twice as many females were widowed than were males. A major reason for this situation is the longer life expectancy of women. Other studies have shown that it is the absence of a spouse to provide assistance and personal care that leads to admission and continued stay in nursing homes (Van Nostrand et al. 1981). Elderly diabetics in nursing homes, like nondiabetic residents, differed considerably from elderly in the community. Diabetics in nursing homes were older and more likely to be widowed. The percent of the very old and of widows was twice as large as for the civilian elderly population. Elderly diabetics in nursing homes were more likely to be female (77 percent), compared to elderly in the community (59 percent) (Table 2).

The use of nursing home care by diabetics has grown substantially. Between 1964 and 1977, the proportion of residents with diabetes increased from 8 to 15 percent (Table 3). The greatest increase occurred between 1964 and 1969, a period of major growth of the nursing home industry. Regardless of the year, rates were highest for diabetics age 65 to 74.

TABLE 2. *Percent of the general population and of nursing home residents age 65 years and older by selected demographic characteristics, United States, 1977*

Demographic Characteristics	General Population (N=23,892,000)	Nondiabetic Nursing Home Residents (N=957,200)	Diabetic Nursing Home Residents (N=168,800)
Age (years)			
65-74	61.3	18.1	22.6
75-84	30.4	40.7	44.8
85+	8.3	41.3	32.6
Sex			
Male	40.6	26.7	22.9
Female	59.4	73.3	77.1
Race			
White	90.8	93.5	91.7
Black and other	9.2	6.5	8.3
Marital status--both sexes			
Married	53.2	12.4	10.4
Widowed	36.4	68.7	73.0
Divorced or separated	4.2	4.5	4.3
Never married	6.2	14.5	12.3
Marital status--males			
Married	75.1	26.5	25.6
Widowed	14.2	45.7	44.7
Divorced or separated	4.8	8.3	8.8
Never married	5.9	19.5	20.9
Marital status--females			
Married	37.7	7.2	5.9
Widowed	52.1	77.0	81.3
Divorced or separated	3.8	3.1	3.0
Never married	6.4	12.7	9.8

SOURCES: Division of Health Care Statistics, 1977 National Nursing Home Survey, National Center for Health Statistics; and Bureau of the Census, U.S. Department of Commerce Current Population Reports, Series P-20(1978) and P-25(1982).

TABLE 3. *Trends in the number of diabetics per 1,000 nursing home residents, United States, 1964-77*

Year	Age (Years)				
	All	<65	65-74	75-84	85+
1964	80.0	66.9	109.8	88.2	52.7
1969	118.7	95.6	155.0	132.4	90.9
1973-74	132.6	112.0	168.1	148.8	109.4
1977	145.5	116.9	180.7	162.7	122.2

SOURCES: Division of Health Care Statistics, 1973-74 and 1977 National Nursing Home Surveys, and 1964 and 1969 Resident Places Surveys, National Center for Health Statistics.

HEALTH STATUS

Living arrangements before admission to a nursing home provide some information on the health of the diabetic prior to admission. Most residents were admitted from a hospital or another nursing home, indicating that they had acute or chronic health problems before they were admitted for their most recent nursing home stay (Table 4). The proportion of diabetics so admitted (60 percent) was slightly higher than for nondiabetics (53 percent). Of patients admitted from a private residence, one of three had lived alone (Table 4).

TABLE 4. *Percent of nursing home residents, by living arrangements before admission, United States, 1977*

Living Arrangement Before Admission	Diabetics (N=189,600)	Nondiabetics (N=1,113,500)
Private or semi-private residence	33.8	41.4
Alone	11.6	14.0
Unknown if with others	2.0	3.0
With others	20.1	24.4
With spouse	4.6	5.7
A health facility	59.8	53.3
Another nursing home	14.5	12.2
General or short-stay hospital	35.4	31.7
Mental hospital	6.6	5.8
Other hospitals and health facilities	3.3	3.6
Other arrangements	6.4	5.3

SOURCE: Division of Health Care Statisitcs, 1977 National Nursing Home Survey, National Center for Health Statistics.

In 38 percent of diagnosed diabetics in nursing homes—71,700 residents—the diabetes was of such impact that it was judged to be the primary diagnosis. Almost all residents with diabetes (98 percent) had other chronic conditions; nearly half (45 percent) had four or more other chronic conditions (Table 5). The most frequent co-existing conditions were those related to heart disease: arteriosclerosis, heart trouble, and hypertension. Rates of the latter two conditions were higher in diabetics. There was no difference in the rate of kidney trouble or of cancer between the two groups. Diabetics had a higher rate of missing arms, legs, or extremities. Rates for mental conditions of senility and chronic brain syndrome were lower.

About one third of residents with diabetes had a vision impairment (Table 6). Four percent were blind, and the sight of another 7 percent was impaired so severely that they could recognize features of a familiar person only if they were within 2 to 3 feet. Although vision problems frequently are associated with diabetes, the vision of diabetic residents was not significantly different from nondiabetics. In comparison to impairment of vision, the prevalence of hearing impairments was less. About one-fourth of diabetics had a hearing impairment and about 3 percent had severe hearing loss. The number of diabetic residents who were deaf was so small that it cannot be reported reliably. Impaired hearing was not significantly different for those with diabetes, compared to nondiabetics. About 70 percent of each group had hearing that was not impaired. Another 22 percent had minor impairments in that they could hear most, but not all, of a conversation.

TABLE 5. *Chronic conditions among diabetic and nondiabetic nursing home residents, United States, 1977*

Chronic Condition	Diabetics Number	Diabetics Percent	Nondiabetics Percent
Diabetes	189,600	100.0	*
Diabetes and other chronic conditions	185,300	97.7	*
One other condition	22,000	11.6	
Two other conditions	38,700	20.4	
Three other conditions	39,100	20.6	
Four or more other conditions	85,500	45.1	
Arteriosclerosis	81,400	42.9	48.4
Heart trouble	75,000	39.6	33.6
Hypertension	51,500	27.2	19.9
Senility	50,100	26.4	32.9
Arthritis/rheumatism	45,800	24.2	24.7
Chronic brain syndrome	39,500	20.8	25.6
Edema	39,500	20.8	17.4
Stroke	34,300	18.1	16.1
Kidney trouble	23,000	12.1	9.8
Mental illness	17,400	9.2	11.8
Missing arm, leg, or extremity	14,200	7.5	1.6
Cataracts	12,200	6.4	6.1
Hip fracture	11,700	6.2	8.7
Chronic respiratory disease	8,600	4.5	7.0
Cancer	8,500	4.5	5.0
Anemia	8,300	4.4	5.6
Bed sores	6,500	3.4	2.6
Glaucoma	5,800	3.1	2.5

*Category not applicable.

SOURCE: Division of Health Care Statisitcs, 1977 National Nursing Home Survey, National Center for Health Statistics.

TABLE 6. *Vision and hearing status of nursing home residents, United States, 1977*

Vision and Hearing Status at Best Correction	Diabetics Number	Diabetics Percent	Nondiabetics Percent
Total residents	189,600	100.0	100.0
Vision			
Sight not impaired	128,000	67.5	67.1
Cannot read newsprint, can watch TV at 8-12 feet	38,500	20.3	18.7
Cannot watch TV at 8-12 feet, can recognize familiar persons at 2-3 feet	13,300	7.0	6.5
Blind	8,300	4.4	2.7
Unknown	-	-	4.9
Hearing			
Hearing not impaired	138,800	73.2	68.9
Can hear most of conversation	42,400	22.4	21.6
Can hear only a few words or loud noises	5,500	2.9	4.6
Deaf	-	-	0.7
Unknown	-	-	4.2

-Estimate unreliable.

SOURCE: Division of Health Care Statisitcs, 1977 National Nursing Home Survey, National Center for Health Statistics.

A major measure of the need for long-term care is the extent of limitation in performing activities of daily living (Van Nostrand et al. 1981). These include personal care tasks (bathing, dressing, using the toilet room, continence, and eating) and mobility (walking or confined to bed or chair). Because these activities are basic to independent living, persons who require assistance from another person or use special equipment to perform the activity are at high risk for admission to a nursing home. Residents with diagnosed diabetes were limited in performing these basic activities for daily living (Table 7).

- Nine of ten required assistance in bathing
- Seven of ten required assistance in dressing and walking
- Five of ten required assistance in using the toilet room
- Four of ten were incontinent
- Three of ten required assistance in eating

Residents with diagnosed diabetes were more likely to be limited in walking or confined to bed or chair. This limitation may have been the consequence of their higher rates of heart trouble or missing legs, feet, or toes (Table 5).

TABLE 7. *Nursing home residents with diabetes, by limitations in activities of daily living, United States, 1977*

	Diabetics		Nondiabetics
Limitations in Activities of Daily Living*	Number	Percent	Percent (N=1,113,500
Total residents	189,600	100.0	100.0
Limited in specific activities of daily living			
Bathing	165,300	87.2	86.2
Dressing	129,200	68.2	69.7
Using toilet room	100,200	52.9	52.5
Mobility (walking, chairfast, bedfast)	132,000	69.6	65.5
Continence (bowel and bladder)	84,300	44.5	45.4
Eating	55,800	29.4	33.1
Index of limitations in activities of daily living			
Not limited in any activities listed	15,100	7.9	9.8
Limited in only one activity	26,100	13.8	12.1
Limited in bathing and one other activity	22,700	12.0	12.2
Limited in bathing, dressing, and one other activity	14,800	7.8	8.6
Limited in bathing, dressing, using toilet room, and one other activity	19,600	10.3	9.5
Limited in bathing, dressing, using toilet room, mobility, and one other activity	32,800	17.3	15.3
Limited in all six activities	40,500	21.4	23.6
Other combinations	18,100	9.5	8.8

*Requires help of another person or special equipment.

SOURCE: Division of Health Care Statisitcs, 1977 National Nursing Home Survey, National Center for Health Statistics.

The index of limitations in activities of daily living is a measure that permits classification of individuals according to a hierarchy based on limitations listed in Table 7 (Katz et al. 1963, 1970). About 38 percent of residents with diagnosed diabetes were severely limited. This included 17 percent who were limited in five activities and another 21 percent who were limited in all six activities. The proportions of diabetics and nondiabetics who were severely limited were similar.

SERVICES AND TREATMENTS

Seven of every 10 residents with diabetes had a physician visit within the month previous to the survey (Table 8). The majority of visits occurred inside the nursing home (88 percent) and on a regularly scheduled basis (86 percent). Services given at the last visit included an examination (89 percent of diabetic residents), a prescription (68 percent), and an order for laboratory tests (38 percent). The physician services received by residents with diagnosed diabetes did not differ significantly from those received by nondiabetics with one notable exception: twice as many laboratory tests were ordered for residents with diabetes, probably accounted for by urine and blood tests used in monitoring diabetic patients. A greater proportion of residents with diabetes received some level of nursing care; 42 percent received intensive nursing care and 47 percent received limited nursing care (Table 8).

TABLE 8. *Percent of nursing home residents receiving physician services and nursing care, United States, 1977*

Physician Services* and Nursing Care	Diabetics	Nondiabetics
Time since last physician visit		
Less than 1 month	72.0	68.2
1 month or more	28.0	31.8
Services given at last visit		
Examination	88.9	88.3
Treatment	16.4	14.9
Prescription	67.7	62.9
Order for lab tests	37.5	16.5
Other	6.4	5.7
Location of last visit		
Inside nursing home	88.2	86.1
Outside nursing home	11.8	13.9
Arrangement for physician services		
Regularly scheduled visits	86.4	84.6
On-call visits	12.6	13.7
Other arrangements	-	1.7
Nursing care during previous 7 days		
Intensive nursing care: bowel/bladder retraining, catheterization, full bed bath, intravenous injection, oxygen therapy, tube or intravenous feeding	42.0	44.2
Limited nursing care: apply sterile dressing, blood pressure, temperature/pulse/respiration check, hypodermic injection, enema, irrigation	46.7	39.7
Personal care: administration of treatment/medicine, help with bathing/dressing/eating, rub, special diet	11.0	15.0

*Excludes 4 percent of 189,600 diabetics and 4.4 percent of nondiabetics who received no physician visits while in the facility.

-Estimate unreliable.

SOURCE: Division of Health Care Statisitcs, 1977 National Nursing Home Survey, National Center for Health Statistics.

About 87 percent of diabetics received a special diet, in contrast to only 36 percent of nondiabetics (Table 9). The most notable difference was in the receipt of a diabetic diet; 81 percent of diabetics received a diet which controlled calories and certain carbohydrates. This is not surprising because diet, along with medication and exercise, is a major component in the treatment of diabetics. About one in every three nursing home residents received some type of therapy. This ratio was the same for both diabetic and nondiabetic residents. Recreation therapy was the type received most frequently (Table 9). Even though 70 percent of diabetics were limited in walking or confined to bed or chair (Table 7), only 15 percent received physical therapy. This percent was no different from that of nondiabetics who were less limited in mobility. In 1973-74, more diabetic residents than nondiabetics received a medication (Table 9), and virtually all diabetics received one or more medications. The most frequent drugs taken by diabetics were diabetic agents and tranquilizers. Differences in the use of cardiovascular medications were significant: more diabetics took diuretics, cardiac glycosides, and antihypertensives. This drug-use pattern probably was related to the higher rates of heart trouble and hypertension for diabetic residents (Table 5).

TABLE 9. *Percent of nursing home residents receiving special diets, medications, and therapy, United States, 1973-74 and 1977*

Service	Diabetics	Nondiabetics
Special diet		
All types	87.2	36.1
Diabetic diet	81.3	0.8
Low sodium	10.1	14.9
Weight loss	2.2	3.3
Soft diet	2.0	9.0
Bland diet	1.2	3.8
Therapy		
Recreation therapy	21.9	19.7
Physical therapy	14.7	13.6
Counseling by social worker	8.6	6.7
Occupational therapy	6.8	5.7
Reality orientation	6.3	6.7
Counseling by mental health worker	-	1.4
None of the above therapies	63.7	65.2
Medications		
One or more	99.0	95.5
Diabetic agents (insulin, oral hypoglycemics)	65.5	-
Tranquilizers	43.2	46.2
Stool softeners	35.9	33.0
Vitamins or iron	35.4	36.2
Diuretics	35.3	26.4
Analgesics	35.2	35.1
Hypnotic-sedatives	34.1	32.8
Cardiac glycosides	31.6	24.2
Antihypertensives	14.4	10.6
Anti-infectives	9.7	8.3
Antidepressives	9.2	8.4
Anti-inflammatory agents	7.8	7.4
Antianginal drugs	5.2	4.3
Anticoagulants	1.5	1.1
Other	42.5	44.7

-Estimate unreliable.

SOURCES: Division of Health Care Statistics, 1977 (diet, therapy) and 1973-74 (medication) National Nursing Home Surveys, National Center for Health Statistics.

COST AND SOURCES OF PAYMENT

The cost of nursing home care is the most rapidly growing component of health care expenditures. Costs are projected to increase dramatically by the end of the decade (Van Nostrand et al. 1981). In 1983, public expenditures paid for nearly 50 percent of the cost, mainly through Medicaid, a Federal-State program that pays for health care for the poor (Gibson et al. 1984). Although not all poor qualify for Medicaid benefits, Medicaid can be used to identify, in a gross way, persons who are poor. If Medicaid is used as the criterion for poverty, more diabetic than nondiabetic nursing home residents were poor (56 versus 47 percent) (Table 10). This poverty may have been of recent occurrence or of lifetime duration. Because the cost of a lengthy nursing home stay can be catastrophic, some persons in nursing homes spend their life savings and assets to pay for their care and become eligible for Medicaid. Others may have entered the nursing home poor, as diabetics in the general population were more likely to be in low income families.

The most usual primary sources of payment for residents with diabetes were Medicaid (56 percent) and their own income or family support (33 percent) (Table 10). The average charge per resident for care received in the nursing home was (in 1984 dollars) $1,429 per month or over $17,000 per year. Given that the median duration of stay was 85 days, the average cost per median stay was $3,900. Monthly charges for care for residents with diabetes did not differ significantly from charges for all residents.

TABLE 10. *Primary source of payment, and charge for care per nursing home resident, United States, 1977*

Primary Source of Payment Used by Resident	Percent of Residents		Average Monthly Charge for Care, 1984*	
	Diabetics (N=189,600)	Nondiabetics (N=1,113,500)	Diabetics (N=189,600)	All Residents (N=1,303,100)
All sources	100.0	100.0	$1,429	$1,350
Own income or family support	33.1	39.3	1,415	1,352
Medicaid	55.6	46.5	1,496	1,412
Skilled care	25.5	19.1	1,795	1,711
Intermediate care	30.1	27.4	1,243	1,196
Medicare	1.5	2.1	-	2,287
Other government assistance or welfare	5.1	6.6	-	996
All other sources	4.8	5.4	-	862

*1977 costs updated to 1984 costs by applying the medical care component of the Consumer Price Index.

-Estimate unreliable.

SOURCE: Division of Health Care Statisitcs, 1977 National Nursing Home Survey, National Center for Health Statistics.

LENGTH OF STAY AND DISCHARGES

The median duration of stay in nursing homes was 13 days longer for diabetics than for nondiabetics (Table 11). However, nearly one-third stayed less than 1 month. Fourteen percent of all discharges from nursing homes in 1976 were of persons with diabetes. About 74 percent of diabetics were alive when discharged, although 10 percent of these subsequently died in another health facility. For every three live discharges with diabetes, one was discharged to "home" (i.e., a private or semiprivate residence) and two to another health facility. Over half of all diabetics discharged alive entered a general hospital. Such a discharge implies that the health of the diabetic had deteriorated to such an extent that the more intensive services of a hospital were necessary. In comparison to persons without diabetes, a larger percent of those with diabetes were discharged to general hospitals.

Of elderly diabetics who died in the nursing home, males accounted for 2 percent of all deaths in the United States in 1976 and females accounted for 4 percent (Table 12).

TABLE 11. *Percent of nursing home discharges, by duration of stay, discharge status, and living arrangement after live discharge, United States, 1976*

Outcomes of Care	Discharges with Diabetes (N=156,800)	Discharges without Diabetes (N=960,700)
Duration of stay		
Less than 1 month	30.6	34.1
1 month to less than 3 months	20.4	20.0
3 months to less than 6 months	11.6	12.2
6 months or more	37.5	33.8
Median duration	85 days	72 days
Discharge status		
Discharged dead	25.4	26.0
Discharged alive	74.4	73.8
Died after discharge to another facility	10.1	7.8
Living arrangement after live discharge		
Private or semi-private residence	31.2	38.1
A health facility	65.7	57.5
Another nursing home	12.0	13.3
General or short-stay hospital	51.8	39.4
Other hospitals and health facilities	2.0	4.8
Other arrangements	3.1	4.7

SOURCE: Division of Health Care Statisitcs, 1977 National Nursing Home Survey, National Center for Health Statistics.

TABLE 12. *Deaths in nursing home discharges as percent of total deaths, United States, 1976*

Age (Years) and Sex	Total U.S. Deaths	Percent of Total Deaths	
		All Discharges	Discharges with Diabetes
65+			
Both sexes	1,245,100	21.8	3.0
Males	624,800	14.4	2.0
Females	620,300	29.2	4.0
85+			
Both sexes	304,500	37.9	4.4
Males	113,100	27.5	3.7
Females	191,400	44.1	4.7

SOURCE: National Center for Health Statistics. 1977 National Nursing Home Survey, Final Mortality Statistics, 1976. Monthly Vital Statistics Report, Vol. 26, No. 12. Supp. DHEW Pub. No. (PHS) 78-1120.

IMPLICATIONS OF THESE DATA

Targeting of care. Because a greater percent of diabetics in nursing homes required nursing care, diabetics admitted to nursing homes should be targeted to those homes providing skilled or intensive nursing care. This should ensure that the services available match diabetics' health care needs.

Physical therapy. The delivery of appropriate physical therapy to diabetics with mobility limitations should be studied further. This is important to the functioning of the 70 percent of diabetics who were limited in walking or were confined to bed or chair. Although more diabetics had such a limitation, the portion receiving physical therapy (15 percent) was not different from that for the less limited nondiabetic.

Use of multiple drugs. The greater use of diuretics, cardiac glycosides, and antihypertensives to treat coexisting cardiovascular conditions of diabetics should be studied to minimize drug reactions.

Community-based services. Studies of the appropriate mix of community-based services should be conducted to identify ways to decrease the rate of diabetics in nursing homes so that it moves toward that in households. These services include home health care, adult day care, home delivered meals, transportation, chore services, and the like. Such community services might prevent or delay admission. They might also shorten the length of stay by providing support services for diabetics discharged from nursing homes.

Training of health personnel. Because 15 percent of nursing home residents are diabetic, information on the special care needs of elderly diabetics should be incorporated into training of health personnel who work in nursing homes. Training should be included in the basic degree programs as well as continuing education for physicians, nurses, and allied health personnel. It also should include in-service training of nurses aides because they comprise the majority of nursing home staff.

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CHAPTER XXVIII. DISABILITY AMONG ADULT DIABETICS

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SUMMARY

Disability is a multifaceted phenomenon (Nagi 1977, Stewart et al. 1978), but no matter which facet of disability is examined, adult diabetics are more likely to be disabled than are adults in the general population. Diabetics are about twice as likely to report ever having other chronic conditions, including cataracts, glaucoma, arteriosclerosis, hypertension, heart attacks, other heart trouble, strokes, and kidney trouble. Impairments, particularly the absence of major extremities and severe visual impairments, are also relatively more frequent among diabetics than they are among nondiabetics. Adult diabetics are more likely than adults generally to report having "any trouble," as well as "a lot of trouble," performing everyday life activities such as walking long distances, using stairs or inclines, sitting for long periods, and lifting or carrying something as heavy as 25 pounds. Diabetics are more likely than nondiabetics to be limited in their usual activities, whether those be working, keeping house, going to school, being retired, or something else. They are more likely than the general population of adults to be work-disabled and to be severely so. Diabetics are more likely to have limited mobility both inside and outside their neighborhood and to need the assistance of other persons in carrying out essential activities of daily living, particularly bathing and dressing. Diabetics, particularly diabetic men, are more likely to participate in a public program for disability than is the case for persons generally.

The prevalence of each type of disability varies among diabetics. Some types of disability (e.g., arteriosclerosis, heart attack, stroke) are more common among men; others (e.g., visual and orthopedic impairments) are more common among women. Most types of disability are relatively more frequent among older diabetics. In general, the more education people have and the higher the annual income of the family in which they live, the less likely they are to be disabled. Diabetics residing within metropolitan areas are generally less likely to have various types of disability than those living outside these areas. In a significant number of instances, diabetics living in the West have the lowest rates of disability. Although diabetics are much

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more likely to be disabled than the general population, irrespective of how disability is defined, when they are compared to nondiabetics with other chronic conditions these differentials are considerably reduced, and, in some cases, even reversed.

Over half of adult diabetics are estimated to be limited in their activities because of one or more chronic conditions or impairments. But of these only about 30 percent attribute their limitation to diabetes, and only 15 percent identify diabetes as the main cause of their limitation. Diabetics with limitation of activity are much more likely to perceive their health as only fair or poor and to have higher rates of restricted-activity days, bed-disability days, and work-loss days than diabetics who are not limited. About 30 percent of diabetics with limitation of activity due to diabetes account for 70 percent of all restricted-activity days due to diabetes.

Between 1965 and 1979-81, both diabetes causing limitation of activity and limitation of activity among diabetics appear to have increased. The percent of diabetics with diabetes causing limitation has clearly increased, but the percentage of diabetics with limitation of activity due to one or more chronic conditions or impairments has been more stable. Underlying this latter stability, however, are offsetting trends among various age categories of diabetic men and women.

INTRODUCTION

This profile of disability among adult diabetics assesses several different facets of disability, including chronic complications (Ellenberg 1978, Krall 1978), impairments (Feller 1981), functional incapacities (Haber 1977, Posner 1980), inability to perform usual daily activities such as working and other major social roles (Wilson and Drury 1981), limitation of mobility (Wilder 1974), needing the assistance of a mechanical aid (Black 1980) or the help of other persons to undertake essential daily activities (Katz and Akpom 1976, Feller 1983), and participating in a public program for the disabled (Berkowitz 1979). Each of these is important in understanding disability among diabetics. The primary data source is the National Health Interview Survey (NHIS) of the National Center for Health Statistics (NCHS) (Howie and Drury 1978, Jack and Ries 1981, Jack 1981, Bloom 1982). In these surveys, diabetes was ascertained by querying respondents whether they had had doctor visits, hospital stays, or disability days for diabetes, and by the direct question "Do you have diabetes?" Limitation due to chronic conditions and impairments was differentiated from limitation due to short-term, but often frequent illnesses such as influenza, by determining the duration of the condition/impairment or by ascertaining the presence of conditions that are known to be chronic, e.g., arteriosclerosis. Data from the 1978 Survey of Disability and Work carried out by the Social Security Administration are also used to clarify selected aspects of the disability profile of adult diabetics (Bye and Schechter 1982). In this latter survey, respondents were classified as diabetic if they reported that they had diabetes that a doctor had told them about.

In comparing various indicators of disability between diabetics and the general population, rates are compared among specific age groups because of the older age structure of the diabetic population and the general increase in disability with age. In addition, the relative risk of disability among diabetics versus the general population in the United States has also been assessed by using age-standardized rates. In this age-standardizing procedure, the age-specific rates among diabetics have been applied to the age structure of the general population to generate "synthetic" rates of disability over the entire diabetic age range. These rates have then been compared to that of the general population to develop a relative risk (risk ratio) of disability that is not confounded by age. Data have not been shown separately for nondiabetics, but their rates of disability are virtually identical to those of the general population.

RELATIVE PREVALENCE OF DIFFERENT TYPES OF DISABILITY AMONG ADULT DIABETICS VERSUS THE GENERAL POPULATION

Diabetics have higher rates of limitation of activity due to chronic conditions and impairments than do adults generally (Table 1). This differential occurs in each age group examined, but is highest for younger diabetics. Rates of limitation of activity in diabetic females are similar to those in diabetic males, as is the case for their nondiabetic counterparts. When age-standardized rates of specific types of disability are examined, persons 20 years and over with known diabetes are still more likely to be disabled than are persons generally (Table 2). Some types of disability are more prevalent than other types, both among diabetics as well as among the general population. Having a chronic condition or an impairment or being limited in major activity are far more common than participating in a public program for the disabled. Being limited in mobility due to a chronic condition or impairment and needing help with one or more personal care needs are the least prevalent types of disability among diabetics and also among the general population.

TABLE 1. *Percent of diabetics and the general population with any limitation of activity due to one or more chronic conditions or impairments, United States, 1979-81*

Sex and Age (Years)	General Population	Diabetics	Ratio, Dm/Gen Pop
Both sexes			
20+	19.3	56.5	2.9
20-44	9.2	36.1	3.9
45-64	23.8	55.3	2.3
65+	45.5	65.6	1.4
Men			
20+	19.8	55.0	2.8
20-44	9.9	33.8	3.4
45-64	25.0	52.7	2.1
65+	48.6	66.5	1.4
Women			
20+	18.9	57.6	3.0
20-44	8.6	37.7	4.4
45-64	22.7	57.7	2.5
65+	43.4	65.0	1.5

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

TABLE 2. *Age-standardized* percent of persons age 20 years and over with different indicators of disability in the general population (GP) and among diabetics (DM), United States, 1977*

	Males			Females		
Disability Indicator**	GP	DM	Risk Ratio	GP	DM	Risk Ratio
One or more selected medical conditions	26.9	47.9	1.8	27.5	56.6	2.1
One or more selected impairments	31.3	45.5	1.5	24.2	36.6	1.5
Limited in usual activity due to chronic conditions or impairments	20.2	44.1	2.2	17.3	39.2	2.3
Participation in public disability programs	8.2	18.0	2.2	4.0	9.7	2.4
Limited in mobility due to chronic conditions	3.3	7.6	2.3	3.6	8.7	2.4
Need help in personal care activities	1.0	2.8	2.8	1.1	3.0	2.7

*Age-adjusted by the direct method to the civilian, noninstitutionalized population for 1977 using three age groups.

**See Tables 3, 4, 8, 9, and 10 for detail.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1976 and 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics.

EYE AND VASCULAR CONDITIONS

At times the word "disability" is used to refer to the presence of chronic medical conditions. In the 1976 NHIS (Black 1977), respondents (both diabetics and nondiabetics) were asked whether or not they had ever had any of the conditions shown in Table 3, which presents the age-standardized rates. Even with age taken into account, the relative risk of these conditions, or one or more of these conditions, among persons with known diabetes was about twice that of the general population.

TABLE 3. *Age-standardized* rate per 1,000 persons age 20 years and over of certain medical conditions, United States, 1976*

Medical Condition	General Population	Diabetics	Risk Ratio
Cataracts	36.9	67.7	1.8
Glaucoma	10.5	25.7	2.4
Arteriosclerosis	27.5	67.8	2.5
Hypertension	169.8	376.5	2.2
Heart attack	32.7	78.2	2.4
Other heart trouble	51.2	120.0	2.3
Stroke	13.9	36.3	2.6
Kidney trouble	68.3	139.7	2.0
One or more of the above conditions	278.1	531.9	1.9

*Age-adjusted by the direct method to the civilian, noninstitutionalized population for 1977 using three age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1976 National Health Interview Survey data provided by the Division of Health Interview Statistics.

IMPAIRMENTS

Disability is used at times to refer to impairments, that is, chronic or permanent defects resulting from disease, injury, or congenital malformation (Feller 1981). The notion of an impairment calls attention to a decrease in or loss of ability to perform various functions, particularly those of the musculoskeletal system and sense organs. Disability, in the sense of an impairment, includes functional losses such as loss of useful vision, hearing, partial or complete paralysis, back or spine problems, and a missing extremity. The age-adjusted rates of such impairments, or one or more of these impairments, were higher for persons with diabetes than for the general population in the 1977 NHIS (Table 4). The largest differences occurred for absence of major extremities and severe visual impairments. Age-specific rates for selected impairments are presented in Appendix A and Appendix B.

TABLE 4. *Age-standardized* rate per 1,000 persons age 20 years and over of selected impairments, United States, 1977*

Impairment	General Population	Diabetics	Risk Ratio
Visual impairments	75.5	158.9	2.1
Severe visual impairments	9.7	24.1	2.5
Other visual impairments	65.8	134.9	2.1
Hearing impairments	108.5	147.8	1.4
Speech defects	7.0	10.0	1.4
Paralysis, complete or partial	9.9	18.7	1.9
Absence of major extremities	2.5	9.7	3.9
Upper only	0.6	2.0	3.3
Lower only	1.8	7.5	4.2
Absence of entire finger(s) or toe(s) only	12.6	24.1	1.9
Orthopedic impairments	119.5	156.8	1.3
Back or spine	62.2	81.7	1.3
Upper extremity and shoulder	16.5	21.0	1.3
Lower extremity and hip	39.5	57.6	1.5
Other and multiple	8.4	12.6	1.5
One or more of the above impairments	276.0	403.5	1.5

*Age-adjusted by the direct method to the civilian, noninstitutionalized population for 1977 using three age categories.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics.

FUNCTIONAL INCAPACITY

Closely related to the notion of disability as an impairment is the concept of disability as functional incapacity. A person may be able to do certain physical activities but only with difficulty, and how much difficulty determines the amount of functional incapacity (Haber 1977, Posner 1980). A typical way of assessing such limitations of functional capacity is by asking individuals if they have any trouble carrying out certain activities central to everyday life. Efforts have been made to develop a list of such activities that are sufficiently culture-free to be used in international studies of disability (Wilson and McNeil 1981). Respondents to the 1978 Survey of Disability and Work, sponsored by the Social Security Administration, were asked whether they had any trouble, or a lot of trouble, with the functions listed in Table 5. On each of the

TABLE 5. *Percent of persons 20-64 years of age with functional capacity limitations, United States, 1978*

Functional Capacity Limitation	General Population	Diabetics	Ratio, Dm/ Gen Pop
Person has "any trouble"			
Walking for long distances	17.5	46.9	2.7
Using stairs or inclines	15.1	42.1	2.8
Standing for long periods	20.5	46.8	2.3
Sitting for long periods	13.0	28.0	2.2
Stooping, crouching, kneeling	18.8	44.4	2.4
Reaching	7.0	20.8	3.0
Using fingers to grasp/handle things	7.0	23.6	3.4
Lifting or carrying objects weighing 25 lbs. or more	28.5	52.6	1.8
Person has "a lot of trouble"			
Walking for long distances	8.3	31.9	3.8
Using stairs or inclines	6.6	27.3	4.2
Standing for long periods	8.7	26.0	3.0
Sitting for long periods	4.6	15.5	3.4
Stooping, crouching, kneeling	7.8	24.9	3.2
Reaching	2.7	9.6	3.6
Using fingers to grasp/handle things	2.8	11.7	4.2
Lifting or carrying objects weighing 25 lbs. or more	7.8	22.0	2.8

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1978 Survey of Disability and Work data provided by the Division of Disability Studies, Office of Research and Statistics, Social Security Administration.

activities, persons with known diabetes were more likely to report having "any trouble" or "a lot of trouble" than the general population.

INABILITY TO PERFORM USUAL ACTIVITIES AND SOCIAL ROLES

Generally, measures of limitation of activity due to a chronic condition or impairment, as well as specific measures of work disability, are based on the concept of disability as inability to perform usual activities and social roles. This type of disability is measured in terms of whether, and to what extent, a person is unable to carry out the activities considered usual for a similarly aged person of the same sex, whether that be working, keeping house, going to school, being retired, or something else (Stewart et al. 1978, Wilson and Drury 1981).

Respondents to the 1977 NHIS were asked a series of questions about their ability to perform their usual activities (Bloom 1982). "Usual activity" in this context was self-defined and included working, keeping house, going to school, being retired, or something else. Specific questions were asked to gauge whether persons were unable, due to a chronic condition or impairment, to perform what they considered their usual activity or were limited in the amount or kind of activity they considered usual for themselves. Persons who were not limited in their usual activity were asked questions to determine whether or not a chronic condition or impairment limited their activities in areas outside the sphere they considered usual for themselves.

Based on responses to these questions, it is possible to identify persons who had any limitation of activity due to a chronic condition or impairment and to distinguish persons who were limited in their major activities from persons who were limited but not in their major activity. Persons with major activity limitation can also be grouped into those unable to perform their usual activity and those limited in the amount or kind of their usual activity. The age-adjusted rates in these categories of limitation of activity were about twice as high for diabetics as for all persons 20 years of age and over (Table 6).

In the past, NHIS estimates of the percentage of persons unable to perform their usual activities have been used as measures of work disability. But since all of the questions needed to derive a measure of work disability from the NHIS were asked only for men (women whose usual activity was not working were not asked a hypothetical work disability question), a conceptually adequate measure of work disability was truly available from the NHIS only for men (Wilson and Drury 1981). Table 7 provides

TABLE 6. *Age-standardized* percent of persons age 20 years and over with limitation of activity due to chronic conditions and impairments, United States, 1977*

Indicator of Limitation	General Population	Diabetics	Risk Ratio
Limited	18.6	41.3	2.2
Limited in usual activity	14.8	33.9	2.3
Unable to perform usual activity	5.2	11.9	2.3
Limited in amount or kind of usual activity	9.1	21.3	2.3
Limited, but not in usual activity	3.8	7.4	1.9
Not limited	81.4	58.7	-

*Age-adjusted by the direct method to the civilian, noninstitutionalized population for 1977 using three age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics.

TABLE 7. *Percent of persons age 20-64 years who are work disabled, United States, 1978*

Work Disability	General Population	Diabetics	Ratio, Dm/ Gen Pop
Work disabled - limited in kind/amount of work/housework due to chronic health condition/impairment	17.4	49.9	2.9
Severely disabled - unable to work regularly or at all	8.8	33.7	3.8
Occupationally disabled - able to work regularly but not full time or at same kind of job	3.9	6.9	1.8
Secondary work limitation - able to work full time, regularly and at same job (including housework), but limited in kind/amount of work	4.7	9.2	2.0
Not work disabled	82.6	50.1	0.6

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1978 Survey of Work and Disability data provided by the Division of Disability Studies, Office of Research and Statistics, Social Security Administration.

information from the 1978 Social Security Administration Survey of Disability and Work; which does not have this limitation (Bye and Schechter 1982), since men and women were asked the same questions. The SSA data show that persons with diabetes were much more likely to be work-disabled, and to be severely disabled, than were persons 20-64 years of age in the general population.

LIMITATION OF MOBILITY

Studies that have asked people to define when persons are sick have invariably shown that persons are considered sick when they are unable to get around by themselves or need the help of other persons to do so (Patrick 1972). Disability, then, sometimes means limitation of mobility, such as in the activities shown in Table 8. The age-standardized rates of mobility limitation were about twice as high in diabetics as in the general population, primarily due to differentials in mobility outside the house and in the use of special aids to get around. Age-specific rates are shown in Appendix C.

TABLE 8. *Age-standardized* percent of persons age 20 years and over with limitation of mobility, United States, 1977*

Type of Mobility Limitation	General Population	Diabetics	Risk Ratio
Needs the help of another person in getting around			
Outside neighborhood	2.0	5.0	2.5
Inside neighborhood	1.4	3.5	2.5
Inside the house	1.0	1.4	1.4
Has to stay in bed all or most of the time	1.0	1.7	1.7
Has to use a special aid all or most of the time to get around (e.g., wheelchair, crutches, special shoes, walker)	1.9	4.0	2.1
Limited in mobility for one or more of the above reasons	3.5	8.2	2.3

*Age-adjusted by the direct method to the civilian, noninstitutionalized population for 1977 using three age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics.

NEED FOR PERSONAL CARE ASSISTANCE

The need for assistance of other persons in carrying out activities of daily living and personal care needs—bathing, dressing, eating, going to the toilet—may define disability, particularly among the elderly (Katz and Akpom 1976). The age-standardized rates of persons needing help with one or more of their essential activities of daily living were higher for diabetics than for the general population primarily due to differences in the rates of needing help bathing and dressing (Table 9). Age-specific rates are shown in Appendix C.

TABLE 9. *Age-standardized* percent of persons age 20 years and over with need of personal assistance in carrying out essential activities of daily living, United States, 1977*

Activity in Which Assistance is Needed	General Population	Diabetics	Risk Ratio
Bathing	1.0	2.2	2.2
Dressing	1.0	1.8	1.8
Going to toilet	0.3	0.5	1.7
Eating	0.2	0.3	1.5
One or more of the above activities	1.0	2.9	2.9

*Age-adjusted by the direct method to the civilian, noninstitutionalized population for 1977 using three age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics.

PARTICIPATION IN PUBLIC PROGRAMS

Receiving help from society at large in the form of participation in a public program designed to meet the needs of persons defined as disabled is an additional way to characterize disability levels (Berkowitz 1979). Respondents to the 1977 NHIS were asked whether they had received any payments or benefits in the past 12 months from the sources shown in Table 10. The age-standardized rate of participation in these programs was about twice as high for diabetics as for the general population. The largest difference occurred for Social Security Disability payments or benefits. Additional information on the characteristics of diabetic SSA disability beneficiaries has been published (SSA 1983). Age-specific rates by sociodemographic characteristics are shown in Appendix D.

TABLE 10. *Age-standardized* percent of persons age 20 years and over by participation in selected public programs for the disabled, United States, 1977*

Public Disability Program	General Population	Diabetics	Risk Ratio
Social Security disability	2.5	6.5	2.6
Workmen's compensation	2.0	3.2	1.6
Veterans disability program	1.0	1.6	1.6
State public welfare or assistance	1.0	2.7	2.7
One or more of the above programs	5.9	13.3	2.3

*Age-adjusted by the direct method to the civilian, noninstitutionalized population for 1977 using three age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics.

VARIATIONS IN LIMITATION OF ACTIVITY

The age-standardized rates of limitation of activity are higher for diabetics than for adults generally, irrespective of age, sex, race, education, marital status, family income, location of residence and region (Table 11). Among diabetics, as among adults generally, the rates are higher for older persons than younger persons, and rates are similar among men and women. Rates of limitation of activity decrease with increasing family income, but relationships with other sociodemographic variables are less clear. Among diabetic men, rates of limitation of activity are higher for those with less than a high school education, the formerly married, and those living in areas

TABLE 11. *Age-standardized* percent of persons age 20 years and over with limitation of activity due to one or more chronic conditions or impairments in the general population (GP) and among diabetics (DM), United States, 1979-81*

	Males			Females		
	GP	DM	Risk Ratio	GP	DM	Risk Ratio
All persons	20.5	44.6	2.2	18.3	48.0	2.6
Race						
White	20.1	45.0	2.2	17.7	47.0	2.7
Black	24.5	43.2	1.8	23.4	52.1	2.2
Education						
<12 years	27.7	54.1	2.0	25.0	48.9	2.0
12 years	18.4	39.8	2.2	15.6	44.1	2.8
13+ years	14.9	34.9	2.3	13.9	43.3	3.1
Marital status						
Married	19.5	41.5	2.1	16.3	44.0	2.7
Formerly married	26.4	61.1	2.3	24.1	57.1	2.4
Never married	23.5	51.1	2.2	18.1	59.0	3.3
Family income						
<$7,000	36.8	62.2	1.7	29.4	61.7	2.1
$7-10,000	30.1	42.3	1.4	21.2	47.4	2.2
$10-15,000	21.9	49.4	2.3	17.1	52.3	3.1
$15-25,000	16.9	37.4	2.2	15.6	42.9	2.8
>$25,000	14.0	36.3	2.6	13.6	34.2	2.5
Residence						
Central city	20.6	41.3	2.0	18.8	55.3	2.9
Outside central city	18.1	40.7	2.2	16.9	38.4	2.3
Nonfarm	23.6	54.5	2.3	20.0	51.4	2.6
Farm	21.3	78.5	3.7	16.3	27.0	1.7
Region						
Northeast	19.3	46.6	2.4	16.2	45.8	2.8
North Central	19.2	42.8	2.2	17.5	39.3	2.2
South	22.4	43.4	1.9	19.8	55.9	2.8
West	20.8	46.4	2.2	19.7	47.0	2.4

*Age-adjusted by the direct method to the civilian, noninstitutionalized population for 1979-81 using three age groups.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

outside Standard Metropolitan Statistical Areas (SMSAs). Among diabetic women, rates are higher for the formerly married and the never married, those living in central cities within SMSAs, and those living in the South.

VARIATIONS IN OTHER TYPES OF DISABILITY

The appendix tables present some details from the 1977 NHIS on the prevalence of chronic conditions, impairments, and other indicators of disability by age and selected sociodemographic characteristics for diabetics and the general population. Some types of disability (arteriosclerosis, heart attacks, strokes, hearing impairments, speech impairments, paralysis, missing fingers or toes, and participation in a public program for the disabled) were relatively more common among diabetic men; others (cataracts, glaucoma, hypertension, kidney trouble, visual impairments, orthopedic impairments, and limitation of mobility) were proportionately more prevalent among diabetic women.

The relative likelihood of various types of disability increased with age. There were exceptions: the rates for missing fingers or toes, back or spine impairments, and other orthopedic impairments did not vary by age. Participation in a public program for the disabled was associated with age in a curvilinear fashion: diabetics 45-64 years of age were more likely to have participated in such a program in the past year than either younger or older diabetics.

In the vast majority of the types of disability analyzed, diabetics with a high school education were less likely to be disabled than those with less education or more education. In some instances, education and family income were inversely associated with the frequency of disability: the more education people had or the higher their family income, the less likely they were to be disabled. The one notable exception to this was arteriosclerosis, where more education but not more income was associated with a higher rate of arteriosclerosis.

Diabetics residing within SMSAs were generally less likely to have various types of disability than persons living outside SMSAs. But in several instances (cataracts, glaucoma, hypertension, severe visual impairments, and speech impairments), the rates of disability were notably higher for diabetics living in the central cities of SMSAs than for diabetics in other location of residence categories.

Finally, with respect to region, diabetics residing in the West had the lowest rates of disability for glaucoma, hypertension, other heart trouble, severe visual impairments, paralysis, orthopedic impairments, and limitation of mobility.

DIABETIC STATUS, CHRONIC CONDITIONS, AND LIMITATION OF ACTIVITY

While diabetics were much more likely to be limited in activity than adults generally, this difference is reduced when diabetics are compared with nondiabetics who had other medical conditions. Diabetics without hypertension were about three times more likely to be limited in their activities than adults without hypertension in the general population (Table 12); however, limitation of activity among hypertensives without diabetes (40.4 percent) was similar to that of diabetics who were not hypertensive (46.6 percent). Similar results are obtained if comparisons are carried out for cataracts, glaucoma, and kidney trouble. Rates for nondiabetics are not shown because they are virtually identical to those for the general population.

TABLE 12. *Percent of persons with chronic limitation of activity, by presence of certain medical conditions, United States, 1976*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
Medical Condition	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons	19.8	55.1	9.4	33.6	24.3	56.4	45.4	63.0
Ever had cataracts								
Yes	55.0	73.4	31.1	31.5	50.3	77.0	58.6	73.7
No	18.5	52.6	9.4	33.6	23.6	54.7	42.8	60.1
Ever had glaucoma								
Yes	53.5	77.1	45.4	77.9	43.5	69.6	60.2	81.2
No	19.5	54.2	9.4	33.0	24.1	56.0	44.8	61.8
Ever had arteriosclerosis								
Yes	74.0	86.2	52.9	100.0	75.3	91.4	74.6	82.8
No	18.3	51.0	9.4	32.1	23.0	53.1	41.5	58.4
Ever had hypertension								
Yes	40.4	65.0	20.9	42.5	39.1	65.8	55.9	69.2
No	15.6	46.6	8.5	30.2	19.9	47.7	39.4	56.2
Ever had heart attack								
Yes	74.3	85.8	59.3	73.3	75.1	91.4	75.6	81.6
No	18.0	50.5	9.2	32.9	21.9	51.1	41.9	58.9
Ever had other heart trouble								
Yes	64.6	84.0	32.2	59.9	67.9	86.4	77.7	85.3
No	17.4	49.3	9.0	31.6	21.6	51.0	40.1	56.4
Ever had stroke								
Yes	81.8	91.6	57.7	32.7	80.7	95.3	84.6	91.1
No	18.9	52.5	9.4	33.6	25.5	54.2	43.1	59.7
Ever had kidney trouble								
Yes	38.2	75.5	19.1	56.5	43.6	80.7	63.1	77.2
No	18.5	51.6	8.9	30.0	22.7	52.2	43.4	60.5

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1976 National Health Interview Survey data provided by the Division of Health Interview Statistics.

In other cases—arteriosclerosis, heart attack, other heart trouble, and stroke—diabetics without the condition were less likely to be limited than persons in the general population with the condition. For example, about 51 percent of diabetics who never had arteriosclerosis were limited in activity, but as many as 74 percent of the general population with arteriosclerosis were limited.

When diabetics with the conditions in Table 12 are compared to the general population with these conditions, diabetics invariably had higher rates. Not only did diabetics with hypertension have higher rates of chronic activity limitation (65.0 percent) than diabetics without hypertension (46.6 percent), they were also more likely to be limited than hypertensives in the general population (40.4 percent). Similarly, more diabetics with arteriosclerosis were limited than those in the general population with arteriosclerosis, who in turn had higher rates than diabetics without arteriosclerosis.

LIMITATION OF ACTIVITY DUE TO DIABETES

In 1979-81 about half of adult diabetics responding to the NHIS were estimated to be limited in activity due to any chronic condition or impairment. Data were also obtained on conditions causing their limitation. When more than one condition was reported they were asked to identify which condition was the main cause and which were secondary causes of activity limitation. Diabetes was a cause of limitation in only about 3 of 10 diabetics, with about half of these reporting it as the main cause and half as the secondary cause (Table 13). There was little variability by age in the percent of diabetics who were limited due to their diabetes, although among younger persons whose diabetes caused any limitation, diabetes was at least three times more likely to be identified as the main cause of limitation.

TABLE 13. *Percent of known diabetics ages 20 years and over with diabetes as the main or secondary cause of limitation of activity, United States, 1979-81*

Sex and Age (Years)	Main or Secondary Cause	Main Cause	Secondary Cause
Both sexes			
20+	30.8	15.3	15.4
20-44	25.2	20.0	5.2
45-64	31.5	14.7	16.8
65+	32.0	14.3	17.7
Men			
20+	30.8	15.2	15.6
20-44	22.0	17.7	4.4
45-64	30.1	14.4	15.7
65+	35.2	15.4	19.9
Women			
20+	30.7	15.4	15.3
20-44	27.3	21.5	5.8
45-64	32.8	14.9	17.9
65+	29.9	13.6	16.3

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

LIMITATION OF ACTIVITY AND SELF-ASSESSED HEALTH STATUS

Diabetics limited in their activities because of one or more chronic conditions or impairments are much more likely to perceive their health as fair or poor, and the more severe the limitation the more likely they are to perceive their health in these unfavorable terms (Table 14).

TABLE 14. *Age-standardized* percent of persons age 20 years and over with self-perceived fair or poor health by activity limitation, United States, 1979-81*

Limitation of Activity	General Population	Diabetics	Risk Ratio
Unable to perform usual activity	72.2	81.8	1.1
Limited in amount or kind of usual activity	50.3	69.5	1.4
Limited, but not in usual activity	27.3	46.2	1.7
Not limited	7.9	26.7	3.4

*Age-adjusted by the direct method to the civilian noninstitutionalized population for 1979-81 using three age groups

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

LIMITATION OF ACTIVITY AND DISABILITY DAYS

Diabetics are more likely to have disability days due to acute and chronic conditions than adults generally. During 1979-81, diabetics averaged 63.7 restricted-activity days and 23.9 bed-disability days annually, with employed diabetics averaging 12.4 work-loss days per year; the comparable numbers for the general population of adults were two to three times lower (Table 15). However, these differences are substantially reduced when limitation of activity is taken into account (Table 15). Diabetics

TABLE 15. *Average number of disability days per person per year associated with acute and chronic conditions among persons 20 years of age and over, United States, 1979-81*

	All Persons		Limited in Activity		Not Limited	
Age (Years) and Disability Days	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
20+						
Restricted-activity days	22.9	63.7	72.1	95.6	11.1	22.4
Bed days	8.0	23.9	23.7	34.3	4.2	10.5
Work-loss days*	5.0	12.4	13.8	17.5	4.1	9.9
20-44						
Restricted-activity days	15.5	51.7	62.1	93.0	10.8	28.3
Bed days	5.7	17.9	19.9	24.6	4.2	14.1
Work-loss days	4.8	14.8	14.4	22.1	4.0	12.1
45-64						
Restricted-activity days	27.1	62.2	80.4	98.5	10.5	17.2
Bed days	9.1	24.4	26.4	36.1	3.7	9.9
Work-loss days	5.6	12.5	14.8	18.8	4.2	9.4
65+						
Restricted-activity days	40.3	70.2	71.0	93.4	14.6	25.9
Bed days	13.6	25.7	23.7	34.4	5.3	9.0
Work-loss days	4.3	6.1	6.8	6.5	3.4	5.8

*Work-loss days are for currently-employed persons only.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

with limitation of activity had higher numbers of disability days due to diabetes than diabetics who were not limited, but the highest levels of disability days due to diabetes occurred among diabetics with chronic activity limitation caused by their diabetes (Table 16).

Studies of the health characteristics of limited persons have frequently noted that even though persons with limitation of activity represent only about 14 percent of the general population, they account for a disproportionate share of disability days (Wilder 1976). This is also true for diabetics. About 30.7 percent of diabetics ages 20 years and older who were limited by their diabetes accounted for 69.5 percent of all restricted activity days due to diabetes (Figure 1).

TABLE 16. *Average number of disability days due to diabetes per diabetic 20 years and over per year, United States, 1979-81*

Disability Days and Age (Years)	All Diabetics	Not Limited in Activity	Limited Due to Chronic Conditions or Impairments	Limited Due to Diabetes
Restricted-activity days				
20+	20.8	5.6	32.5	47.0
20-44	15.0	7.6	28.1	35.2
45-64	19.7	2.9	33.4	43.2
65+	24.2	8.3	32.5	54.8
Bed-disability days				
20+	6.4	2.3	9.6	13.5
20-44	4.5	3.3	6.7	9.6
45-64	6.2	1.8	9.7	13.2
65+	7.4	2.4	10.0	15.2
Work-loss days among currently-employed diabetics				
20+	2.8	1.9	4.7	4.8
20-44	2.1	2.3	1.5	1.9
45-64	3.6	1.8	7.1	7.5
65+	1.0	1.2	-	-

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

TRENDS IN DISABILITY AMONG DIABETICS

Between 1965 and 1979-81, both limitation of activity among diabetics and diabetes causing limitation of activity increased, although the latter showed a larger increase (Table 17). With regard to the first of these measures, there were offsetting trends among various age groups of diabetic men and women. Among young and middle-aged diabetic men, and among middle-aged diabetic women, limitation of activity increased; among older diabetic men, and among young and elderly diabetic women, limitation of activity decreased. Possible reasons for these changes have been discussed (Wilson and Drury, 1981, 1984).

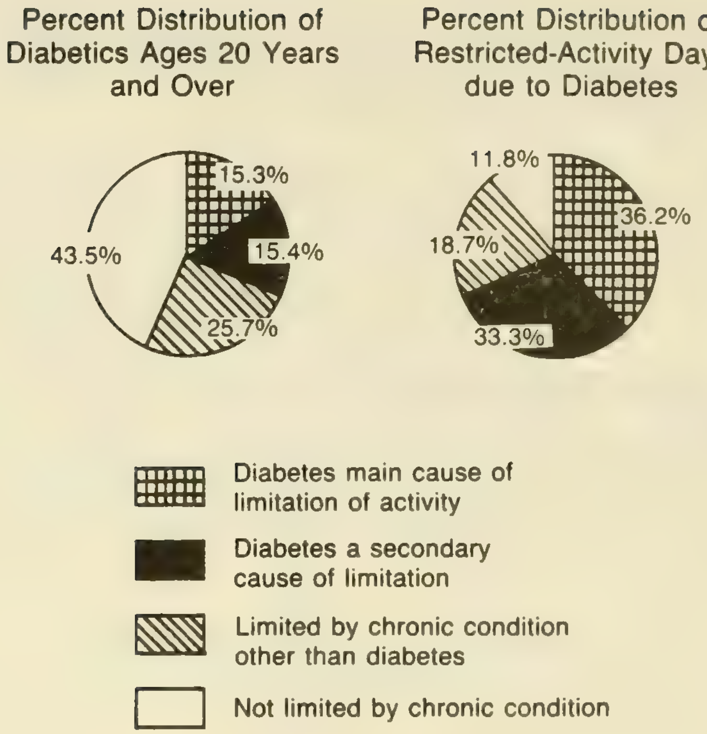

FIGURE 1. *Percent distribution of diabetics ages 20 years and over, and of restricted activity days due to diabetes, by limitation of activity and diabetes as a cause of limitation, United States, 1979-81*

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

TABLE 17. *Trends in the percent of diabetics who are limited in activity, United States, 1965 and 1979-81*

Sex and Age (Years)	Limited Due to One or More Chronic Conditions or Impairments		Limited Due to Diabetes	
	1965	1979-81	1965	1979-81
Both sexes				
20+	54.2	56.5	20.9	30.8
20-44	31.9	36.1	15.0	25.2
45-64	46.4	55.3	17.6	31.5
65+	70.6	65.6	26.6	32.0
Men				
20+	50.9	55.0	21.3	30.8
20-44	20.8	33.8	11.4	22.0
45-64	45.3	52.7	18.3	30.1
65+	70.2	66.5	29.0	35.2
Women				
20+	56.6	57.6	20.6	30.7
20-44	42.3	37.7	18.3	27.3
45-64	47.1	57.7	17.1	32.8
65+	70.9	65.0	25.1	29.9

SOURCE: Computed by the Division of Epidemiology and Health Promotion, National Center for Health Statistics, from 1965 and 1979-81 National Health Interview Survey data provided by the Division of Health Interview Statistics.

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APPENDIX A. *Percent of persons with one or more selected impairments,* United States, 1977*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons	27.5	50.1	18.1	30.6	30.3	43.7	53.7	66.1
Sex								
Men	30.7	52.6	21.8	38.0	35.0	48.9	55.6	63.5
Women	24.8	48.3	14.6	25.5	26.0	39.3	52.4	68.0
Race								
White	28.0	50.7	18.5	31.1	30.5	44.5	53.8	65.6
All other races	23.7	46.7	15.2	27.7	28.2	39.8	52.9	69.9
Black	25.0	48.3	16.2	30.1	29.5	40.5	53.6	72.4
Education								
<12 years	37.1	56.5	21.5	31.1	35.1	47.5	56.3	69.1
12 years	23.2	41.3	16.9	27.3	27.3	41.2	49.9	56.8
13+ years	22.7	44.8	17.5	36.5	27.7	38.7	50.0	62.4
Family income								
<$7,000	40.4	60.2	23.4	35.6	41.6	54.5	58.7	69.1
$7-10,000	29.9	51.7	19.8	31.4	34.5	48.3	50.8	66.8
$10-15,000	24.7	41.4	18.0	31.8	30.5	35.2	49.3	58.2
$15-25,000	21.6	38.7	16.4	25.2	27.2	37.1	48.9	59.7
>$25,000	21.1	41.3	15.8	31.1	25.3	38.4	45.2	63.6
Location of residence								
Within SMSA	26.2	48.3	18.1	31.4	28.7	42.7	51.6	63.9
Central city	27.6	49.9	18.5	29.3	30.3	44.5	41.8	67.0
Outside central city	25.2	46.8	17.7	33.4	27.5	41.1	51.5	61.0
Outside SMSA	30.4	53.9	18.1	28.4	33.9	46.1	57.2	69.8
Nonfarm	30.6	53.7	18.4	28.4	34.2	45.8	57.6	69.5
Farm	28.6	55.8	15.1	28.5	31.6	48.6	53.5	73.8
Geographic region								
Northeast	26.1	52.0	17.7	30.1	27.1	43.3	49.7	70.0
North Central	27.7	49.2	18.5	27.6	30.4	43.0	52.8	63.9
South	27.7	49.4	17.1	31.7	30.8	43.5	56.4	65.7
West	28.9	50.5	19.6	33.2	33.9	46.5	55.8	64.3

*Includes persons reported to have one or more of the following types of impairments: visual, hearing, speech, complete or partial paralysis, absence of major extremity, absence of entire finger(s) or toe(s) only, orthopedic impairment, and other impairments not elsewhere classified.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX B. *Prevalence per 1,000 persons of certain impairments, United States, 1977*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
Impairment	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
Visual impairments								
All persons	75.2	218.8	35.8	106.3	68.2	152.9	220.1	344.0
Men	81.1	195.8	48.8	150.0	82.2	146.7	204.5	278.1
Women	69.9	236.3	23.6	76.6	55.5	158.2	231.2	390.6
Severe visual impairments								
All persons	9.6	46.1	1.4	2.4	6.0	30.1	44.5	83.6
Men	8.0	30.9	1.5	0.0	6.1	28.8	37.2	46.8
Women	11.1	57.7	1.2	4.0	5.8	31.2	49.5	109.8
Hearing impairments								
All persons	108.0	219.6	43.6	80.0	123.7	157.8	292.7	352.1
Men	126.4	248.6	55.0	81.2	156.2	197.7	338.1	385.4
Women	91.8	197.5	32.9	79.1	94.1	123.9	260.8	328.5
Speech defects								
All persons	7.0	11.3	6.1	10.1	7.3	5.4	9.5	18.5
Men	9.7	14.2	8.4	18.2	10.0	8.3	13.8	20.0
Women	4.7	9.1	4.0	4.7	4.7	3.0	6.5	17.5
Paralysis (complete or partial)								
All persons	9.8	29.8	4.3	7.7	10.8	21.9	26.4	48.6
Men	10.8	38.3	4.6	8.1	13.0	32.3	30.3	59.0
Women	8.9	23.3	4.0	7.5	8.8	13.2	23.7	41.2
Orthopedic impairments								
All persons	119.3	170.6	99.1	139.1	131.0	175.5	164.4	178.6
Men	124.5	165.9	110.9	147.6	136.7	176.1	150.3	160.6
Women	114.8	174.1	88.0	133.3	125.8	175.0	174.3	191.3
Absence of fingers or toes								
All persons	1.3	2.4	0.8	2.4	1.6	2.3	2.2	2.6
Men	2.2	4.1	1.3	5.3	2.8	4.1	4.2	3.7
Women	0.4	1.2	0.2	0.4	0.5	0.8	0.8	1.9

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX C. *Percent of persons with certain limitations of activity due to chronic conditions or impairments, United States, 1977*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
One or more types of mobility limitation*								
All persons	3.5	13.9	1.0	2.8	3.2	9.1	12.4	24.2
Men	3.1	11.9	1.0	3.5	3.2	8.2	10.7	20.2
Women	3.8	15.4	1.0	2.3	3.2	10.0	13.7	27.0
Need help getting around outside their neighborhood								
All persons	2.0	9.0	0.4	1.2	1.6	5.5	8.4	16.6
Men	1.5	5.8	0.4	1.2	1.3	3.2	6.0	11.0
Women	2.5	11.5	0.4	1.2	1.8	7.4	10.0	20.5
Need help getting around inside their neighborhood								
All persons	1.4	6.5	0.2	1.0	1.0	3.3	6.0	12.3
Men	1.0	4.1	0.2	1.2	0.9	2.5	4.1	7.4
Women	1.7	8.2	0.3	1.0	1.0	4.0	7.3	15.8
Need help getting around inside their homes								
All persons	1.0	2.7	0.1	0.0	1.0	1.8	2.6	5.0
Men	0.5	2.1	0.1	0.0	0.5	1.0	1.9	4.5
Women	1.0	3.2	0.1	0.0	1.0	2.5	3.0	5.4
Have to stay in bed all or most of the day								
All persons	1.0	2.4	0.2	1.2	1.0	1.1	2.1	4.4
Men	1.0	1.8	0.2	2.4	1.0	0.6	1.8	3.2
Women	1.0	2.8	0.2	0.4	0.7	1.5	2.2	5.3
Need help bathing, dressing, eating, going to the toilet								
All persons	1.0	5.0	0.2	1.0	1.0	3.1	4.1	9.0
Men	1.0	4.2	0.2	1.7	1.0	2.0	3.7	8.0
Women	1.1	5.7	0.2	0.4	1.0	4.0	4.5	9.8

*Includes persons who were limited because of a chronic condition or impairment in getting around inside or outside their neighborhoods, inside their home, who are bedridden, or who need the help of a special aid to get around.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX D. *Percent of persons who received selected types of disability payments or benefits* in the past 12 months, United States, 1977*

	Age (Years)							
	20 and over		20-44		45-64		65 and over	
	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics	General Population	Diabetics
All persons	5.9	13.6	4.5	11.1	9.2	20.3	4.5	7.0
Sex								
Men	8.2	18.7	5.9	15.0	12.7	27.4	6.7	9.1
Women	4.0	9.7	3.1	8.4	6.0	14.3	2.9	5.5
Race								
White	5.6	13.1	4.2	10.8	8.8	20.5	3.9	6.0
Black	9.1	17.8	7.0	13.2	13.1	20.8	10.0	15.8
Education								
<12 years	9.4	17.3	7.8	19.1	13.9	27.4	5.6	8.4
12 years	5.0	11.4	4.3	8.6	6.9	15.3	3.1	6.3
13+ years	3.5	6.7	2.9	5.7	5.6	10.2	2.2	1.6
Family income								
<$7,000	10.4	17.6	8.5	18.7	20.0	31.1	5.8	7.7
$7-10,000	7.4	16.0	5.9	10.8	13.4	28.0	3.2	6.1
$10-15,000	5.5	12.1	4.2	11.1	8.7	15.0	4.0	8.4
$15-25,000	3.9	9.1	3.1	7.0	5.4	11.8	3.7	4.1
>$25,000	3.1	6.6	2.5	6.3	3.9	6.6	2.9	7.1

*Includes disability payments or benefits from any of the following: Workman's Compensation, Social Security Administration, Veterans Administration, or State public assistance or welfare. There was little variation by location of residence or geographic region.

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from 1977 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

CHAPTER XXIX. MORTALITY FROM DIABETES

Maureen I. Harris, Ph.D., M.P.H., and Paul S. Entmacher, M.D.

SUMMARY

Mortality statistics based on death certificates have become important data in estimating the national impact of diseases. In 1982, 34,583 deaths were attributed to diabetes as the underlying cause of death on death certificates filed in the United States. This corresponds to a mortality rate of 14.9 deaths per 100,000 living population, accounts for 1.8 percent of all deaths occurring in the United States in 1982, and results in diabetes being ranked as the seventh leading cause of death. In 96,847 deaths in 1978, the most recent year for which multiple cause data are available, diabetes was listed on the certificate as a contributing cause of death, accounting for an additional 5 percent of all deaths. Since 1970, there has been a 19 percent decline in the underlying cause death rate from diabetes.

The majority of death certificates listing diabetes also list a cardiovascular condition, whether diabetes is selected as the underlying cause or as a contributing cause of death, and cardiovascular diseases appear to be excessive among persons with diabetes. Ischemic heart diseases are involved in about 60 percent of diabetes deaths and cerebrovascular diseases in about 25 percent. Cancer-related deaths seem to be fewer than expected.

Diabetes is a more frequently recorded cause of death among white diabetics than among blacks, and among male diabetics than among females. It is particularly associated with death in older persons in the United States, and about 76 percent of diabetes deaths recorded on death certificates occur at age 65 years and older, and 46 percent at age 75 years and older. Survival for 20 years after diagnosis of diabetes may be about 50-80 percent of expected survival in the general adult population.

DEATH CERTIFICATES AND SELECTION OF DIABETES AS THE UNDERLYING CAUSE OF DEATH

Coding of Causes of Death on Death Certificates

In the United States, deaths are recorded on death certificates that contain space for listing certain standard information (Figure 1). Among this information is the

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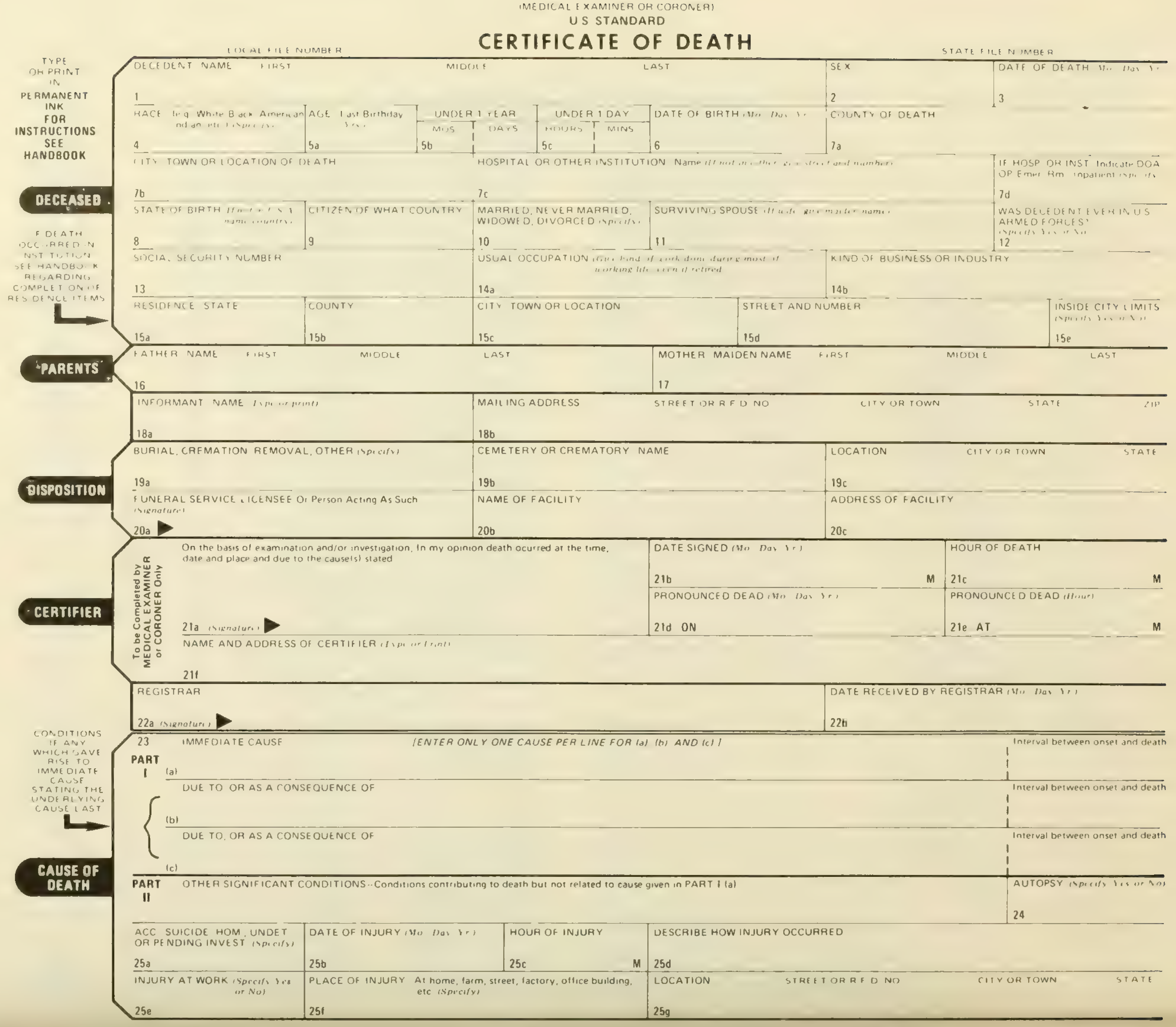

condition or disease that is considered to be the primary or originating cause of the death (the underlying cause). It is this cause that is used in calculating national death rates and for ranking the leading causes of death in the United States. Also listed on the certificate are other diseases and conditions that the underlying cause precipitated or that were also present at death (contributing causes).

The dichotomy between underlying and contributing causes of death is important for understanding national data because, as will be explained below, among all deaths where diabetes is listed on the death certificate, it is selected as the underlying cause in only about one-fourth, with the result that three-fourths of recorded deaths of diabetics are not attributed to diabetes. In addition, as explained below, it is estimated that diabetes is not listed on the death certificate in about half of the deaths of persons with diabetes, leading to reporting of diabetes as the underlying cause in only about 12 percent of deaths of diabetics and causing further underestimation of diabetes in national mortality statistics.

There are internationally accepted rules, promulgated by the World Health Organization, for selecting which condition on the death certificate should be considered the underlying cause of death (NCHS 1975). The lowest listed condition on Line 23, Part I, of the certificate is generally selected (Figure 1). In Michigan (Dodson 1978) and South Carolina (Wheeler 1979), when diabetes was on Part I of the death certificate (Figure 1, lines 23a-c) it was selected as the underlying cause in 82 percent; in Ohio it was selected in 93 percent (Belloni 1978). Further, when diabetes was not selected as the underlying cause, in over 90 percent it was on Part II of the certificate in these three States. This same percentage apparently applies nationally: in 1969, for all certificates where diabetes was a contributing cause of death, it was listed on Part II in 94 percent (Pitts 1976). Part II of the death certificate contains "other significant conditions - conditions contributing to death but not related to cause in Part I." Thus, nationally, diabetes is considered only to be a "significant condition" in the majority of deaths in which diabetes appears on the certificate.

Rate of Selection of Diabetes and Other Diseases as Underlying Causes of Death

Diabetes is selected as the underlying cause of death in about 26 percent of death certificates on which it is listed (Table 1). In contrast, the major leading causes of death are selected much more frequently as the underlying cause, which partially accounts for their being ranked higher than diabetes. For example, in 1978, cardiovascular diseases were selected in 78 percent, cancer in 88 percent, and cerebrovascular diseases in 61 percent of certificates on which these conditions were listed (NCHS 1984).

There are variations by age, sex, and race in selecting diabetes as the underlying cause of death when it is listed on a death certificate in the United States. The probability of selecting diabetes declines with increasing age at death (Table 1). This may be because diabetes at young ages is a more obvious disease and hence more likely to be listed as the underlying cause, or it may be that many causes of death at older ages compete for underlying cause status. The latter is indicated by the rise with age in the number of conditions listed on diabetes death certificates (see Table 10). Diabetes is selected more often for nonwhites than for whites and, within races, for females than for males (Table 2). It is not known why these selection rates differ by race and sex; they could be artifactual or have a true biologic basis.

There appear to be local variations in selecting diabetes as the underlying cause of death (Table 3). In the United States in 1978, diabetes was selected as the underlying cause in 26 percent of certificates in which diabetes was listed as a cause of death.

TABLE 1. *Percent of death certificates mentioning diabetes for which diabetes was selected as the underlying cause of death, by age at death, United States, 1978*

Age at Death (Years)	Number of Deaths With Diabetes Coded as: Underlying Cause	Contributing Cause	Total	Underlying Cause Deaths as Percent of Total Diabetes-Coded Deaths
All ages	33,841	96,847	130,688	26
0-14	50	31	81	62
15-24	140	99	239	59
25-34	564	325	889	63
35-44	920	1,102	2,022	45
45-54	2,227	4,859	7,086	31
55-64	5,563	15,260	20,823	27
65-74	9,629	29,741	39,370	24
75-84	10,069	31,618	41,687	24
85+	4,674	13,797	18,471	25

SOURCE: Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

TABLE 2. *Percent of death certificates mentioning diabetes for which diabetes was selected as the underlying cause of death, by race and sex, United States, 1969 and 1978*

Race and Sex	1969[a]	1978[b]
All	28.5	25.9
White males	25.7	23.3
White females	28.4	26.1
Nonwhite males	37.2	31.4*
Black males	-	31.9
Nonwhite females	39.1	33.5*
Black females	-	33.6

*90 percent of nonwhite male diabetic deaths were deaths in black males; 94 percent of nonwhite female diabetic deaths were deaths in black females.

TABLE REFERENCES

a. Pitts, AM. Some notes on the collection of United States multiple cause of death data. Unpublished report on Contract 230-76-0202, Health Resources Administration, DHEW, October, 1976.

b. Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

Local selection rates ranged from 22 percent (Rochester, Minnesota) to 35 percent (Louisiana). There also appear to be temporal changes in selection rates. In national data, and in the two States where different years have been analyzed (Michigan and Nebraska), there has been a decline in more recent years in the percent of certificates for which diabetes was selected as the underlying cause from among all causes of death on certificates that listed diabetes (Table 3). This might have resulted from a

TABLE 3. *Percent of death certificates mentioning diabetes for which diabetes was selected as the underlying cause of death, by location and year, 1955-80*

Reference	Location and Date of Study	Percent Selected as Underlying Cause
a	U.S., 1955	0.40
b	" 1968	0.30
c	" 1969	0.29
d	" 1978	0.26
e	Rochester, Minnesota, 1945-70	0.22
f	Pennsylvania, 1968-69	0.26
g	Vermont, 1969-75	0.21
h	Michigan, 1970-73	0.32
	" 1974-76	0.28
	" 1977-79	0.26
	" 1980	0.24
i	Mississippi, 1972-76	0.31
j	Iowa, 1972-77	0.26
k	Nebraska, 1974-76	0.26
	" 1977-79	0.23
l	Rhode Island, 1976	0.23
m	Maine, 1976-79	0.23
n	Louisiana, 1978	0.35
o	Ohio, 1978	0.26
p	South Carolina, 1979	0.33

*Data sources are all death certificates filed in the United States or the specific State for the dates indicated, with the following exceptions: The Rochester data are based on 3,120 residents with a diagnosis of diabetes; the Pennsylvania data utilized a sample of 300 deaths coded to diabetes and a sample of about 300 deaths without diabetes that were investigated to ascertain the presence of diabetes in the decedent; Mississippi, for which only Health District III data were examined; and South Carolina, for which a 1-in-14 random sample of certificates was examined.

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b. Diabetes Data Compiled 1977. DHEW Pub. No. (NIH) 78-1468.
c. Pitts, AM. Some notes on the collection of United States multiple causes of death data. Unpublished report on Contract 230-76-0202. Health Resources Administration, DHEW, October, 1976.
d. Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.
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temporal decline in the preference for selecting diabetes as the underlying cause from among all conditions present at death, or simply from a decrease in listing diabetes as a condition present at death.

Variations in the Frequency with Which Diabetes Appears on Death Certificates of Diabetics

Several local studies have documented the underreporting of diabetes on death certificates of persons known to be diabetic (Table 4). The Rochester data are probably the most valid, as the diagnosis of diabetes was documented in the decedent's medical record. However, in only 32 percent of deaths of diabetics in Rochester was diabetes listed on the death certificate either as an underlying or a contributing cause of death in 1945-70.

A similar percent of reporting appears in the United States data of 1969 (Table 4). Estimates of reporting diabetes as the underlying cause of death in the United States were calculated using underlying cause death data, and incidence and prevalence data of the United States Health Interview Surveys, as follows: During 1968-73, the average annual number of newly diagnosed cases of diabetes was 565,000; however, the annual prevalence increase was only 200,000, indicating that 365,000 diabetics died each year (565,000 minus 200,000); an annual average of 38,200 death certificates listed diabetes as the underlying cause of death; and thus nationally only about 10 percent of deaths of diabetics (38,200/365,000) may have been attributed to diabetes as the underlying cause.

Differentiation of Diabetes Death Certificate Data into Deaths from IDDM and Deaths from NIDDM

Although the death certificate contains space for listing the various causes of death, differentiation of diabetes deaths into IDDM and NIDDM from death certificate data has never been made in the United States. Only inferences can be made, based on the age at death and the known prevalence of these two types of diabetes in different age groups. For example, it is estimated that approximately 40 percent of diabetics under age 35 are IDDM (Harris 1982), and it might be assumed that the majority of deaths occurring under age 35 are in IDDM diabetics. Conversely, at least 95 percent of diabetics above age 65 years appear to be NIDDM, and virtually all diabetes on death certificates where the age at death is older than 65 years might be considered to be NIDDM.

THE DIABETES UNDERLYING CAUSE DEATH RATE, AND THE LEADING UNDERLYING CAUSES OF DEATH

Number of Deaths and Death Rate from Diabetes

Table 5 shows two of the most commonly quoted diabetes mortality data, the number of deaths attributed to diabetes as the underlying cause of death, and the diabetes death rate (number of diabetes underlying cause deaths divided by the number of 100,000 living persons in the United States). Diabetes is recorded as the underlying cause of death primarily in the older populations of the United States. In 1980, only 5

TABLE 4. *Estimates of reporting deaths of diabetics on death certificates*

			Percent of Deaths of Diabetics Reported as:		
Reference	Location, Date	Data Source	Underlying Cause	Contributing Cause	Total
Deaths in Known Diabetics					
a	Rochester, Minnesota, 1945-70	3,120 residents with a diagnosis of diabetes documented in medical records	7	25	32
b	Vermont, 1969-75	196 in-hospital deaths of persons with diabetes on their hospital charts	16	59	75
c	Atlanta and Memphis, 1969-78	404 deaths among 1,047 black diabetics observed over a 9-year period	8.4	-	-
d	U.S. life insurance applicants, 1951-70	1,478 deaths of diabetics among 10,538 applicants for life insurance	7.8	-	-
Death Certificate Data					
e,f	U.S., 1969	1968 and 1973 Health Interview Surveys incidence and prevalence data to estimate number of diabetics; all death certificates filed in the U.S., 1969, to determine number of diabetes deaths as underlying or contributing cause	10	25	35
g	Pennsylvania, 1968-69	All death certificates filed in the State; for 0.13% w/o mention of diabetes, contacted decedent's physician to determine presence of diabetes	14	40	54
h	New York (excl. N.Y. City), 1979	Random sample (2%) of cardiovascular disease death certificates; of those w/o mention of diabetes, contacted attending MD, hospital, nursing home to determine presence of diabetes	-	-	45

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percent of diabetes underlying cause deaths occurred at age 45 years or younger and 72 percent occurred at age 65 years or older. Among all deaths in the United States in 1980, 11 percent occurred under age 45, and 67 percent occurred at ages 65 years and older. These differences between diabetes deaths and all deaths probably exist because diabetes is a more prevalent disease in older populations and hence more frequently a cause of death in older persons.

The data in Table 5 illustrate the higher rate of death from diabetes traditionally attributed to blacks, particularly to black females, and the higher rates in females compared to their male counterparts of the same race. While the general pattern of increasing death rates with increasing age is similar for all race and sex groups, the increase among black males and females occurs at earlier ages than in whites, and blacks have higher death rates than whites in each age group. These data may reflect the higher prevalence of diabetes in blacks, particularly black females (Harris 1982), but part of the difference may be attributable to the higher percent reporting of diabetes as the underlying cause of death in blacks versus whites (Table 2). The small number of diabetes deaths in persons other than white or black do not permit analysis by age groups.

TABLE 5. *Number of deaths and underlying cause death rate from diabetes and from all causes of death, United States, 1980*

	Diabetes Underlying Cause Deaths (a)		All Deaths (b)	
Age at Death (Years) Sex, and Race	Number of Deaths	Rate Per 100,000*	Number of Deaths (Thousands)	Rate Per 100,000*
All persons	34,851	15.4	1,990	878.3
Under 25	181	0.2	113	-
25-34	572	1.5	50	135.5
35-44	900	3.5	58	227.9
45-54	2,188	9.6	133	584.0
55-64	5,789	26.7	292	1,346.3
65-74	10,111	64.8	466	2,994.9
75-84	10,134	131.1	517	6,692.6
85+	4,976	222.1	358	15,980.3
White males	12,125	13.2	934	983.3
Under 25	65	0.2	57	-
25-34	260	1.7	27	171.3
35-44	373	3.5	28	257.4
45-54	853	8.9	68	698.9
55-64	2,217	24.6	158	1,728.5
65-74	3,682	61.1	246	4,035.7
75-84	3,314	128.9	229	8,829.8
85+	1,361	221.7	118	19,097.3
White females	16,734	17.3	805	806.1
Under 25	68	0.2	15	-
25-34	192	1.3	10	65.4
35-44	283	2.6	16	138.2
45-54	741	7.4	38	372.7
55-64	2,231	21.9	90	876.2
65-74	4,583	58.2	164	2,066.6
75-84	5,507	124.6	241	5,401.7
85+	3,138	219.4	216	14,979.6

(Continued)

TABLE 5. (Continued)

	Diabetes Underlying Cause Deaths (a)		All Deaths (b)	
Age at Death (Years) Sex, and Race	Number of Deaths	Rate Per 100,000*	Number of Deaths (Thousands)	Rate Per 100,000*
Nonwhite males				
All ages	2,200	14.6	141	936.5
Nonwhite females				
All ages	3,783	22.7	110	660.6
Black males**	2,010	16.1	130	1,034.1
Under 25	26	0.4	15	-
25-34	55	2.8	8	407.3
35-44	120	9.8	9	689.8
45-54	216	21.2	15	1,479.9
55-64	489	57.5	25	2,873.0
65-74	577	102.1	29	5,131.1
75-84	415	182.8	21	9,321.6
85+	112	211.3	9	16,098.8
Black females**	3,534	25.3	103	733.3
Under 25	20	0.3	9	-
25-34	58	2.6	3	150.0
35-44	107	7.2	5	323.9
45-54	328	26.2	10	768.2
55-64	739	70.0	17	1,561.0
65-74	1,143	147.7	24	3,057.4
75-84	806	224.5	22	6,212.1
85+	333	314.2	13	12,367.2

*Death rate: Number of underlying cause deaths in each age/race/sex group divided by the number of 100,000 living persons in the group.

**Blacks constitute a subset of nonwhites and account for the majority of nonwhite deaths.

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Rank of Diabetes as a Leading Cause of Death in the United States

Another major mortality statistic is the ranking of diseases as the leading causes of death. Only underlying cause of death data are considered in these United States rankings. In 1976, at the time of the National Commission on Diabetes, diabetes was ranked as the sixth leading underlying cause of death. In 1979, the Ninth International Classification of Diseases (ICD) was instituted, resulting in a reclassification of more deaths as being due to chronic obstructive pulmonary disease, which changed this disease category's rank from ninth to fifth and dropped diabetes to the seventh leading underlying cause of death.

The 15 leading underlying causes of death in 1980 are shown in Table 6, where they are ranked according to the number of deaths attributed to each underlying cause of death. The cardiovascular and malignant diseases groups are by far the most frequent causes of mortality. This is not surprising, as both of these categories are composed of many conditions that can lead to death, and deaths from all of these are summed to produce the ranks of first and second. For example, "Diseases of the Heart" encompasses rheumatic heart disease, hypertensive heart disease, myocardial infarction, angina, chronic ischemic heart disease, and various other forms of heart disease. "Malignant Neoplasms" includes cancers at all sites in the body. Only when we reach "Diabetes Mellitus," the seventh leading cause, is the ranking based on just two diseases that are closely related, insulin-dependent diabetes and noninsulin-dependent diabetes. When individual diseases are considered, for example, underlying cause deaths from diabetes are about as frequent as underlying cause deaths from arteriosclerosis or breast cancer and are twice as frequent as underlying cause deaths from hypertensive disease or leukemia. When considering diabetes as a cause of death in national statistics, it is only counted as the underlying cause in about one-fourth of certificates on which it appears. When both underlying and contributing causes are summed, many diseases that are considered important medical problems rank below diabetes (Table 7). Indeed, none of the individual cancers rank higher than diabetes, nor do any of the individual diseases in the categories "Accidents," "Chronic Obstructive Pulmonary Disease," or "Pneumonia/Influenza," the fourth, fifth, and sixth leading underlying causes of death.

The relative ranking of mortality from diabetes varies somewhat by sex. For example, in 1978, diabetes ranked as the ninth leading underlying cause of death among white and nonwhite males; for females, the comparable rankings were sixth and fifth, respectively.

TABLE 6. *The 15 leading underlying causes of death, and selected components, United States, 1980*

Rank[a]	Cause of Death (and ICD Number)	Death Rate[b]	Age-Adjusted Death Rate[c]	Number of Deaths	Percent of Total Deaths
-	All causes	878.3	585.8	1,989,841	100.0
1	Diseases of heart (390-398,402,404-429)	336.0	202.0	761,085	38.2
	Rheumatic fever and rheumatic heart disease (390-398)	3.5	2.6	7,836	
	Hypertensive heart disease (402)	9.3	5.9	21,095	
	Hypertensive heart and renal disease (404)	1.6	0.9	3,711	
	Ischemic heart diseases (410-414)	249.7	149.8	565,755	
	Acute myocardial infarction (410)	132.2	85.9	299,584	
	Other acute and subacute forms of ischemic heart disease (411)	2.1	1.4	4,773	
	Angina pectoris (413)	0.2	0.2	561	
	Old myocardial infarction and other forms of chronic ischemic heart disease (412,414)	115.1	62.3	260,837	
	Other diseases of endocardium (424)	3.2	2.0	7,164	
	All other forms of heart disease (415-423,425-429)	68.7	40.8	155,524	

(Continued)

TABLE 6. (Continued)

Rank[a]	Cause of Death (and ICD Number)	Death Rate[b]	Age-Adjusted Death Rate[c]	Number of Deaths	Percent of Total Deaths
2	Malignant neoplasms (140-208)	183.9	132.8	416,509	20.9
	Malignant neoplasms of lip, oral cavity, and pharynx (140-149)	3.8	2.9	8,553	
	Malignant neoplasms of digestive organs and peritoneum (150-159)	48.8	33.0	110,647	
	Malignant neoplasms of respiratory and intrathoracic organs (160-165)	47.9	36.4	108,504	
	Malignant neoplasm of breast (174-175)	15.8	12.5	35,897	
	Malignant neoplasms of genital organs (179-187)	20.5	13.6	46,430	
	Malignant neoplasms of urinary organs (188-189)	7.9	5.2	17,828	
	Malignant neoplasms of all other and unspecified sites (170-173,190-199)	22.4	16.9	50,679	
	Leukemia (204-208)	7.3	5.4	16,533	
	Other malignant neoplasms of lymphatic and hematopoietic tissues (200-203)	9.5	6.9	21,438	
3	Cerebrovascular diseases (430-438)	75.1	40.8	170,225	8.6
4	Accidents and adverse effects (E800-E949)	46.7	42.3	105,718	5.3
	Motor vehicle accidents (E810-E825)	23.5	22.9	53,172	
	All other accidents and adverse effects (E800-E807,E826-E949)	23.2	19.5	52,546	
5	Chronic obstructive pulmonary diseases and allied conditions (490-496)	24.7	15.9	56,050	2.8
6	Pneumonia and influenza (480-487)	24.1	12.9	54,619	2.7
7	Diabetes mellitus (250)	15.4	10.1	34,851	1.8
8	Chronic liver disease and cirrhosis (571)	13.5	12.2	30,583	1.5
9	Atherosclerosis (440)	13.0	5.7	29,449	1.5
10	Suicide (E950-E959)	11.9	11.4	26,869	1.4
11	Homicide and legal intervention (E960-E978)	10.7	10.8	24,278	1.2
12	Certain conditions originating in the perinatal period (760-779)	10.1	d	22,866	1.1
13	Nephritis, nephrotic syndrome, and nephrosis (580-589)	7.4	4.5	16,753	0.8
14	Congenital anomalies (740-759)	6.2	d	13,938	0.7
15	Septicemia (038)	4.2	2.6	9,438	0.5
-	All other causes	95.6	-	-	10.9

[a] Rank based on number of deaths.

[b] Number of deaths per 100,000 living persons.

[c] Age-adjusted to the United States population structure of 1940.

[d] Since deaths from these causes occur mainly among infants, rates adjusted to the total population of 1940 are not calculated.

SOURCE: National Center for Health Statistics. Monthly Vital Statistics Report, Vol. 32, August 11, 1983.

TABLE 7. *35 diseases frequently listed on death certificates, United States, 1978*

ICD Number	Name of Condition	Total Number of Mentions
412.3	Chronic ischemic heart disease, nonhypertensive	429,847
410.9	Acute myocardial infarction, nonhypertensive	295,326
427.2	Cardiac arrest (unspecified)	247,872
440.9	Arteriosclerosis (unspecified)	184,044
427.0	Congestive heart failure	164,682
436.9	Acute cerebrovascular disease without hypertension	135,032
250.9	Diabetes mellitus, acidosis or coma unmentioned	125,474
486	Pneumonia (unspecified)	107,709
199.0	Multiple malignant neoplasms (sites unspecified)	106,345
162.1	Malignant neoplasm of bronchus and lung	103,247
412.4	Nonischemic cardiovascular disease, nonhypertensive	99,876
782.4	Acute symptomatic heart failure (unspecified)	83,834
437.9	Ischemic cerebrovascular disease without hypertension	68,963
796.0	Certain ill-defined conditions	(60,000)*
792	Uremia	(60,000)
485	Bronchopneumonia (unspecified)	53,490
433.9	Cerebral thrombosis without hypertension	51,602
593.2	Renal disease (unspecified)	47,721
038.9	Septicemia (unspecified)	46,509
492	Emphysema	42,364
174	Malignant neoplasm of breast	40,602
153.8	Malignant neoplasm of large intestine (part unspecified)	39,254
450	Pulmonary embolism and infarction	39,179
777	Immaturity (unqualified)	(36,000)
412.2	Nonischemic cardiovascular disease, hypertensive	34,067
514	Pulmonary congestion and hypostasis	32,816
185	Malignant neoplasm of prostate	30,936
429.9	Heart disease (unspecified)	30,913
N854	Intracranial injury (unspecified)	(28,000)
569.9	Disease of intestine and peritoneum (unspecified)	(27,000)
794	Senility without mention of psychosis	26,699
197.7	Secondary malignant neoplasm of liver	(25,000)
431.9	Cerebral hemorrhage without hypertension	25,231
573.9	Disease of liver (unspecified)	(23,000)
571.9	Cirrhosis of liver (unspecified)	21,972

*Numbers in parentheses indicate provisional data.

SOURCE: Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

DIABETES DEATH RATES IN THE DIABETIC POPULATION: THE CASE FATALITY RATE

Table 8 shows the estimated rate of death from diabetes, recorded as both the underlying and contributing causes of death, per 1,000 diabetics. This might be termed the "case fatality" rate, and it is a better estimator than the death rate (Table 5) of the mortality impact of diabetes, since it is the number of death certificates listing diabetes divided by the number of persons who reported having been diagnosed as diabetic (rather than divided by the number of persons in the entire United States population, as is done in calculating the death rate).

A very different pattern is seen than the more commonly quoted data, the death rate. The predominance of black female mortality in Table 5 is absent. The overall case fatality rate (24.1 per 1,000 or 2,410 per 100,000) is 155 times higher than the death rate (15.5 per 100,000 in 1978). The overall rate for white diabetics is higher than that for black diabetics, and the rate for males and females of the same race are approximately equal. Within individual age groups, however, male rates are consistently higher than rates for females of the same race. Black males have the highest case-fatality rates in four of the six age groups and white males in the other two. These data imply that the mortality impact of diabetes may be greater in males than females, and greater in whites than in blacks.

TABLE 8. *Number of deaths coded to diabetes (underlying and contributing cause) per estimated 1,000 diabetics, United States, 1978*

Age at Death (Years)	All Diabetics	White Males	White Females	Black Males	Black Females
All ages	24.1	25.4	25.3	19.7	18.6
0-24	1.9	2.0	1.9	6.2	2.7
25-44	4.0	5.4	2.7	7.2	4.4
45-54	7.3	9.2	5.5	8.3	9.1
55-64	14.5	15.7	12.9	19.9	15.0
65-74	29.4	31.9	27.7	33.6	27.8
75+	76.6	86.4	76.7	74.6	44.8

SOURCE: Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics, and diabetes prevalence data from the 1979-81 National Health Interview Surveys, NCHS.

MULTIPLE CAUSES OF DEATH ON DIABETES DEATH CERTIFICATES

Diabetes Underlying Cause of Death Categories

In 1979, the Ninth Revision of the International Classification of Diseases changed the way diabetes underlying cause deaths were coded. Instead of only the two categories used previously (diabetes with and diabetes without acidosis or coma), new categories were instituted to permit more detailed description of diabetes deaths. The distribution of diabetes underlying cause deaths among these categories, however, shows that in 77 percent of certificates, none of the "classic" diabetes complications were listed or selected as the underlying cause (Table 9). It is unknown whether they were truly not present in the decedent or simply were not known to be present, or whether the causes of death were not fully reported on the certificate.

Underlying Versus Contributing Cause of Death

Underlying cause of death data seriously underestimate the contribution of diabetes to mortality, because many persons with diabetes die as a result of complications or other diseases that are themselves ascribed as the underlying cause of death. Diabetes more often appears on death certificates only as a contributory cause of death (Tables 1 to 4), and these deaths do not appear in national rankings (Table 6). Further, it is estimated that diabetes is not recorded on the death certificate in the majority of deaths of diagnosed diabetics (Table 4); unfortunately these "missing" deaths cannot be analyzed. While death of a diabetic person from an automobile accident might not be

TABLE 9. *Underlying cause deaths attributed to diabetes and its complications, United States, 1980*

ICD Number	Diabetes Complication	Number of Deaths	Percent
250	Diabetes mellitus (all)	34,851	100.0
250.0	Diabetes without mention of complication classifiable to 250.1-250.9	26,663	76.5
250.1	Diabetes with ketoacidosis and no mention of coma	1,772	4.7
250.2	Diabetes with coma (with or without acidosis)	1,240	3.6
250.3	Diabetes with renal manifestations	2,034	5.9
250.4	Diabetes with ophthalmic manifestations	126	0.4
250.5	Diabetes with neurologic manifestations	221	0.6
250.6	Diabetes with peripheral circulatory disorders	2,029	5.8
250.7	Diabetes with other specified manifestations	675	1.9
250.9	Diabetes with unspecified complications	91	0.3

SOURCE: Harris, MI, National Diabetes Data Group, from death certificates filed in 1980 with the Division of Vital Statistics, National Center for Health Statistics.

ascribable to diabetes, many diabetes deaths involve diseases that may be associated with or even caused by diabetes. Underlying cause analysis obscures these associations, while multiple cause analysis permits a method of assessing the importance of diabetes as a cause of death.

More conditions are reported on death certificates of those whose underlying cause of death is diabetes than on the average death certificate. In 1969, 80 percent of death certificates where diabetes was the underlying cause listed two or more additional conditions, compared to only 50 percent for all death certificates (Pitts 1976). The average number of additional conditions listed was 2.41 for diabetes certificates and 1.71 for all death certificates. In 1978, 97.3 percent of diabetes underlying cause certificates mentioned at least one other cause of death and the average number of additional listed conditions was 2.32 (Table 10). A lower average (1.57) of additional conditions was listed on the 2,848 certificates where diabetes with acidosis or coma (ICD 250.0) was the underlying cause of death than on the 30,993 certificates where diabetes without acidosis or coma (ICD 250.9) was the cause of death (2.36 additional conditions) (Harris 1983). The presence of acidosis or coma may bias the person who fills out the death certificate toward not listing other contributing causes of death.

Contributing Causes of Death on Diabetes Underlying Cause Death Certificates

All ages. In the most recent analyses (Harris 1983) as well as in analyses of a decade ago (Pitts 1976), cardiovascular diseases (ICD 390-458) are the conditions that are, by far, the most frequently listed on diabetes underlying cause death certificates. In 1978, on death certificates where diabetes was selected as the underlying cause of death, there was an average of 1.4 cardiovascular conditions listed per certificate (Table 10). This is particularly striking in view of the fact that only 47 percent of all underlying cause deaths were attributed to cardiovascular diseases, and it might be expected that the average number of cardiovascular conditions on diabetes death certificates would be approximately 0.47. Among the cardiovascular diseases, ischemic heart disease stands out as the major contributor to diabetes deaths; other forms of

TABLE 10. *Contributing causes of death in deaths where diabetes was the underlying cause of death, United States, 1978*

Other Conditions Listed on the Death Certificate	ICD Number	All Ages		Age 0-34 Years		Age 35-64 Years		Age 65+ Years	
		Total Number	Average Number Per Certificate	Total Number	Average Number Per Certificate	Total Number	Average Number Per Certificate	Total Number	Average Number Per Certificate
Number of diabetes underlying cause certificates	250	33,841	-	754	-	8,730	-	24,372	-
All listed conditions	000-E999	78,572	2.322	1,326	1.759	19,604	2.246	57,695	2.367
Infectious and parasitic diseases	000-136	2,122	0.063	56	0.074	610	0.070	1,456	0.060
Neoplasms (benign and malignant)	140-239	1,215	0.036	1	0.000	240	0.027	972	0.040
Endocrine, nutritional, metabolic diseases	240-279	1,592	0.047	53	0.070	616	0.071	923	0.038
Blood diseases	280-289	530	0.016	14	0.019	141	0.016	374	0.015
Mental system diseases	290-315	1,244	0.037	15	0.020	275	0.032	954	0.039
Nervous system diseases	320-389	1,648	0.049	69	0.090	414	0.047	1,165	0.048
Cardiovascular system diseases	390-458	48,275	1.427	462	0.613	11,214	1.284	36,592	1.502
Hypertensive diseases	400-404	1,478	0.044	29	0.038	431	0.049	1,016	0.042
Ischemic heart diseases	410-414	20,846	0.616	116	0.154	5,283	0.605	15,445	0.634
Other forms of heart disease	420-429	10,227	0.302	217	0.288	2,661	0.305	7,347	0.301
Cardiac arrest NOS	427.2	4,331	0.128	140	0.186	1,320	0.151	2,870	0.118
Cerebrovascular diseases	430-438	8,214	0.243	57	0.076	1,323	0.152	6,832	0.280
Diseases of arteries, arterioles, capillaries	440-458	7,387	0.218	42	0.056	1,472	0.169	5,862	0.241
Respiratory system	460-519	3,982	0.118	92	0.122	876	0.100	3,014	0.124
Digestive system	520-577	1,872	0.055	54	0.072	684	0.078	1,133	0.046
Genitourinary system	580-629	5,780	0.171	231	0.306	1,994	0.228	3,553	0.146
Nephritis/nephrosis	580-584	1,851	0.055	93	0.123	816	0.093	942	0.039
Other renal diseases	593.2	2,595	0.077	123	0.163	946	0.108	1,525	0.063
Complications of pregnancy	630-678	0	0	-	-	-	-	-	-
Skin/subcutaneous tissue	680-709	978	0.029	7	0.009	226	0.026	745	0.031
Musculoskeletal/connective tissue	710-738	691	0.020	4	0.005	191	0.022	539	0.022
Congenital anomalies	740-759	42	0.001	6	0.008	16	0.002	20	0.001
Perinatal mortality	760-779	4	0.000	-	-	-	-	-	-
Symptoms/ill-defined conditions	780-796	7,661	0.226	219	0.290	1,865	0.214	5,577	0.229
Uremia	792	1,839	0.054	48	0.064	517	0.059	1,274	0.052
Accidents/poisoning/violence	E800-E999	936	0.028	43	0.057	215	0.025	678	0.028

SOURCE: Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

heart disease (a miscellaneous grouping), cerebrovascular disease, and diseases of the arteries, arterioles, and capillaries are also major contributors in the cardiovascular disease category.

Renal diseases (nephritis/nephrosis, other renal disease, uremia) are conspicuous contributors to diabetes underlying cause deaths (Table 10). Only about 7 percent of deaths were associated with influenza and pneumonia, despite the fact that these constitute the sixth leading cause of death. No deaths were associated with diabetes during pregnancy or childbirth, supporting the notion that maternal deaths among diabetic women are no greater than among nondiabetic women. Only one death certificate mentioned suicide, compared to the national rate of 1.4 percent of certificates listing suicide as the underlying cause of death. Accidents and adverse effects were also a rare cause of death, involved in less than 3 percent of deaths, although this category is the fourth leading cause of all deaths.

Cancers, although they are the second leading underlying cause of death, also are underrepresented on diabetes underlying cause death certificates. This does not appear to be solely because cancers were selected over diabetes as the cause of death, since diabetes is also underrepresented on cancer underlying cause death certificates (Harris

TABLE 11. *Percent of diabetes underlying cause death certificates that list certain contributing causes of death, United States, 1969*

		Whites		Nonwhites	
Other Condition and ICD Number	All	Males	Females	Males	Females
Number of death certificates	38,541	13,618	19,050	2,071	3,802
Average number of other conditions per certificate	2.41	2.42	2.47	2.23	2.21
Infectious and parasitic diseases (000-136)	3	<4	5	5	5
Malignant neoplasms (140-209)	3	<4	5	<3	3
Nutritional and metabolic diseases (240-279 except 250)	3	<4	5	5	5
Diabetes mellitus* (250)	4	3	5	6	8
Hypertensive diseases (400-404)	10	7	11	10	13
Ischemic heart diseases (410-414)	62	73	63	43	42
Rheumatic and other heart diseases (390-398, 420-429)	18	22	21	19	16
Cerebrovascular diseases (430-438)	26	22	26	19	26
All other cardiovascular diseases (440-458)	31	29	31	24	24
Influenza, pneumonia, bronchitis, emphysema, asthma (470-493)	10	7	11	10	8
Major digestive and liver diseases (530-573)	5	7	5	5	3
Nephritis and nephrosis (580-584)	3	<4	5	5	5
Congenital anomalies and perinatal conditions (740-779)	<3	<4	<3	0	<2
All other nonexternal conditions (remainder of 000-796)	54	51	53	63	58

*Consists of mentions of 250.9, Diabetes Without Acidosis or Coma, on certificates where 250.0, Diabetes With Acidosis or Coma, was the underlying cause.

SOURCE: Pitts, AM. Some notes on the collection of United States multiple cause of death data. Unpublished report on Contract HRA 230-76-0202, October, 1976.

1983). Whether these data have biological significance in indicating that cancers are less frequent in diabetics than in the general population remains to be ascertained.

In less recent data, the same patterns of diseases on diabetes death certificates also occurred (Table 11). In multiple cause analyses of all death certificates in the United States in 1969, ischemic heart disease was again the most frequent condition listed on diabetes underlying cause death certificates, being listed on 62 percent of all certificates. It was the leading contributing cause for all four race/sex groups, although it was more frequent on death certificates of whites compared to nonwhites. Hypertensive disease, other heart diseases, cerebrovascular disease, and other circulatory diseases were also present on a large percent of certificates.

Age-specific data. For diabetes underlying cause deaths at all ages, and in each age group shown in Table 10, cardiovascular diseases are the major contributing causes of death. Nevertheless there are certain age-related trends. With increasing age at death, cardiovascular diseases become more prominent contributing causes of death; the same age-related trend is seen for all cardiovascular deaths in the United States. Cancer-related deaths also increase with age at death, both for diabetes deaths and for all deaths in the United States. The proportion of diabetes deaths that involve virtually all the other causes of death decline with increasing age at death, probably because the cardiovascular diseases become so predominant at older ages. An alternative explanation is that the other diseases claim the lives of diabetics at ages younger than that at which the cardiovascular diseases have their impact on mortality. For example, the proportion of diabetes underlying cause deaths that involves renal diseases (nephritis, nephrosis, other renal disease, uremia, Table 10) declines with age; this decline could be the result of a mortality impact of renal diseases at ages earlier than that of the cardiovascular diseases.

Diabetes as a Contributor to Death from Other Diseases on Death Certificates

Data for diabetes as a contributing cause of death for all United States deaths (Table 12) substantiate the conclusion that cardiovascular diseases are the conditions most commonly associated with deaths of diabetics. In virtually 75 percent of death certificates where diabetes is a contributing cause of death, some cardiovascular condition is the underlying cause of death. Ischemic heart disease represents the major proportion, constituting 54 percent of all certificates. Very similar percentages were seen in analysis of death certificate data of 1969, indicating that even though the cardiovascular underlying cause death rate has declined since 1969, cardiovascular diseases still represent a disproportionate amount of deaths among diabetics.

CAUSES OF DEATH AMONG DIABETIC PATIENTS

While most diabetics die of cardiovascular diseases, the age at onset of diabetes has an important effect on cause of death. In Joslin Clinic data, 42 percent of those with onset of diabetes at ages under 20 years died from diabetic nephropathy (Table 13). With increasing age at onset, this proportion diminished considerably, while the proportion dying from cardiovascular causes increased. The death rate from cardiovascular diseases in diabetics was generally 2 to 3 times higher than that in the entire population, but was especially higher for diabetics under age 45 years and for the specific cause, renal vascular disease (Table 14).

TABLE 12. *Diabetes as a contributing cause of death: Percent distribution of death certificates listing diabetes as a contributing cause of death, by underlying cause of death, United States, 1978*

		Age at Death (Years)			
Underlying Cause of Death	ICD Number	All	0-34	35-64	65+
Infectious and parasitic diseases	000-136	1.0	6.2	1.5	0.8
Neoplasms (benign and malignant)	140-239	11.1	4.6	12.3	10.7
Endocrine, nutritional, metabolic diseases	240-279	0.5	5.5	0.8	0.4
Blood diseases	280-289	0.2	1.3	0.2	0.2
Mental system diseases	290-315	0.3	1.0	0.6	0.2
Nervous system diseases	320-389	0.5	6.2	0.7	0.5
Cardiovascular system diseases	390-458	75.6	33.2	71.4	77.0
Hypertensive diseases	400-404	1.6	0.2	1.5	1.6
Ischemic heart diseases	410-414	54.2	17.4	55.5	47.1
Other forms of heart disease	420-429	2.4	1.8	3.0	2.2
Cardiac arrest NOS	427.2	0.6	1.3	1.0	0.5
Cerebrovascular diseases	430-438	13.3	4.0	8.1	14.8
Diseases of arteries, arterioles, capillaries	440-458	3.6	0.9	2.7	3.8
Respiratory system diseases	460-519	4.8	14.3	4.0	5.0
Digestive system diseases	520-577	2.8	7.0	4.6	2.3
Genitourinary system diseases	580-629	1.9	5.7	2.1	1.8
Nephritis/nephrosis	580-584	0.6	0.2	1.0	0.5
Other renal diseases	593.2	0.4	0.0	0.6	0.4
Accidents, poisoning, violence	E800-999	1.0	9.9	1.2	0.9
All others - complications of pregnancy, skin diseases, musculoskeletal diseases, congenital anomalies, perinatal mortality, symptoms and ill-defined conditions	630-796	0.4	3.9	0.5	0.3
Total	-	100.0	100.0	100.0	100.0
Number of certificates	-	96,847	455	21,221	75,156

SOURCE: Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

TABLE 13. *Cause of death in diabetic patients attending Joslin Clinic, by age at onset of diabetes, 1956-64*

	Age (Years) at Onset of Diabetes				
	All	<20	20-39	40-59	60+
Cause of Death	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)
All causes	6,800 (100.0)	472 (100.0)	932 (100.0)	3,475 (100.0)	1,921 (100.0)
Cardiovascular	4,613 (67.8)	132 (27.9)	584 (62.7)	2,505 (72.1)	1,392 (72.5)
Renal	615	229	142	190	54
Diabetic nephropathy	389 (5.7)	200 (42.4)	87 (9.3)	87 (2.5)	15 (0.8)
Other renal	226	29	55	103	39
All other causes	1,572	111	206	780	475

SOURCE: Balodimos, MC. In: Marble, A, P White, RF Bradley, and LP Krall, eds. Joslin's Diabetes Mellitus. 11th edition. Philadelphia: Lea and Febiger, 1971. p. 537.

TABLE 14. *Relative mortality from specified causes among diabetic patients (experience of Joslin Clinic patients 1950-1958 traced to 1961, ages 15-74)*

	Ratio: Diabetic to General Population Death Rate*	
Cause of Death	Males	Females
Total vascular disease	2.4	3.4
Ages 15-44	12.2	19.5
Ages 45-74	2.2	3.2
Heart disease	2.0	3.2
Cerebral vascular disease	1.8	2.0
Renal vascular	17.8	17.0
Cancer	1.5	1.6

*Basis of comparison: Vascular disease--mortality among white persons in New England, 1949-51; cancer--mortality among white persons in United States, 1950.

SOURCE: Entmacher, PS, HF Root, and HH Marks. Longevity of diabetic patients in recent years. Diabetes 13:373-77, 1964.

A study of the death certificates of 404 deaths over a 9-year period among 1,049 black diabetics in Atlanta and Memphis found that cardiovascular-renal deaths accounted for 66 percent of all underlying causes of death; sudden death appeared to account for an excessive proportion of deaths. In only 8.4 percent of these 404 deaths was diabetes listed as the underlying cause of death (Vander Zwaag 1983).

The Pima Indians are the population that has the highest recorded prevalence of NIDDM in the world. Female Pimas with diabetes experience death rates higher than that of nondiabetic Pima women but, for males, diabetes has little effect on mortality (Pettitt et al. 1982).

A 4.5-year study of diabetics in Evans County, Georgia, demonstrated an excess risk of cardiovascular mortality among diabetics, of greater magnitude in women than men (Heyden et al. 1980). In the 16-year Framingham, Massachusetts, study, the risk of cardiovascular mortality in diabetic women was 4.5 times as great as in nondiabetic women and twice as great as in nondiabetic men (Gottlieb 1973).

Among 1,478 diabetics who applied for life insurance in 1951-1970 and subsequently died, 56 percent of deaths were attributed to cardiovascular diseases (Table 15).

SURVIVORSHIP AND LIFE EXPECTANCY

Since diabetes is not always reported on death certificates, and since only deaths with diabetes as the underlying cause are routinely tabulated, the life expectancy or survivorship of diabetics in the United States on a national basis has not been calculated from death certificate data. Estimates from clinical patients, insurance applicants and policyholders, and employees of large companies, however, all indicate a reduced life expectancy or survivorship for those with diabetes. However, each of these populations may be subject to selection biases that prohibit generalization of their findings.

Survivorship

Table 16 shows Joslin Clinic data on the likelihood of a diabetic's surviving for given periods of time according to age at diagnosis of diabetes. The data suggest that,

TABLE 15. *Underlying causes of death on death certificates of diabetics applying for life insurance between 1951 and 1970**

Cause of Death	Number	Percent
All causes	1,478	100.0
Cardiovascular diseases	828	56.0
Heart diseases	724	49.0
Cerebrovascular diseases	85	5.8
Other vascular diseases	19	1.3
Renal diseases	86	5.8
Diabetes	115	7.8
Accidents and suicides	67	4.5
All other causes	262	17.8

*Based on 10,538 applicants observed through 1971 and constituting 83,687 person-years of study.

SOURCE: Goodkin, G, et al. Mortality factors in diabetes. Trans Assoc Life Insur Med Dir Am 58:188, 1974.

TABLE 16. *Percent of diabetics still alive and percent relative survival, by age at diagnosis of diabetes, Joslin Clinic, 1939-59*

Sex	Years Since Diagnosis	Age at Diagnosis (Years) 0-19	20-39	40-59	60-79
		Percent Alive (Percent Relative Survival*)			
Males	5	99 (100)	96 (100)	90 (97)	75 (98)
	10	97 (98)	95 (99)	76 (92)	46 (87)
	15	96 (98)	91 (97)	59 (84)	24 (77)
	20	87 (89)	78 (88)	42 (77)	7 (48)
	25	80 (83)	68 (83)	30 (75)	4 (63)
Females	5	97 (97)	96 (97)	92 (97)	74 (88)
	10	95 (96)	94 (96)	80 (89)	48 (75)
	15	95 (95)	89 (92)	62 (78)	27 (63)
	20	86 (87)	84 (89)	43 (64)	9 (40)
	25	82 (83)	78 (86)	28 (55)	3 (35)

*Percent of diabetics surviving compared to survival of the general population of Massachusetts.

SOURCE: Hirohata T, B MacMahon, and HF Root. The natural history of diabetes. I. Mortality. Diabetes 16:875-81, 1967.

among diabetics who experienced onset when they are under 20 years of age, there was little excess mortality during the first 15 years after onset of diabetes and survival was similar to that of the general population. At 25 years after diagnosis, however, survival had decreased to 83 percent of the expected rate. Similar percent survival for youth-onset diabetics was observed in IDDM patients seen at Children's Hospital of Pittsburgh (Dorman et al. 1984) and diabetics in Erie County, New York (Sultz et al. 1972).

Among Joslin Clinic diabetics diagnosed at ages 40 years and older, mortality seemed to be excessive, the percent alive declined sharply with increasing years since diagnosis, and survival relative to the general population was poorer than for young-onset diabetics (Table 16). In the Rochester, Minnesota population, consisting primarily of adult-onset diabetics, survival in 1945-54 was similar to that of adult diabetics seen at the Joslin Clinic in 1939-59, but during 1955-69 the survival rate was higher (Table 17). There was no difference in survival rates between males and females in the Rochester population of diabetics (Palumbo et al. 1976).

TABLE 17. *Percent of diabetics still alive and percent relative survival, by years since diagnosis of diabetes, Rochester, Minnesota 1945-54 and 1955-69*

Years Since Diagnosis	Year of Diagnosis		
	1945-54	1955-69	Total 1945-69
	Percent Still Alive (Percent Relative Survival*)		
1	93 (95)	91 (94)	92 (94)
5	77 (88)	78 (91)	78 (90)
10	59 (79)	61 (87)	60 (85)
15	41 (68)	45 (81)	44 (78)
20	28 (59)	---	30 (69)

*Survival relative to the white population of the Northwest Central United States, 1960.

SOURCE: Palumbo, PJ, et al. Diabetes mellitus--incidence, prevalence, survivorship, and cause of death. Diabetes 25:566-73, 1976.

Life Expectancy

The average age at death in the United States in 1980 was 70.0 years for males of all races and 77.5 years for females of all races.

Life expectancy of diabetics can be estimated from death certificate data of the States of Iowa and Pennsylvania in 1968-73 (Table 18, Figure 2), where multiple cause coding and the availability of estimates of the prevalence of diabetes have permitted estimation of the life expectancy of diabetics among representative populations. However, neither of these data sources provides recent estimates of life expectancy. While the data indicate a greater life expectancy for diabetics than earlier Joslin Clinic data (Marks 1961), they are influenced to some extent by the failure to record diabetes on all death certificates of diabetics, which could lead to some degree of overestimation of the years of life remaining for diabetics. These computations allow only an estimation of the expected number of years of life remaining at a given age without regard to the duration or age at onset of diabetes.

TABLE 18. *Life expectancy among diabetics, Iowa, 1972-73, and Pennsylvania, 1968-69*

Age (Years)	Expected Number of Years of Life Remaining					
	Iowa 1972-73			Pennsylvania 1968-69		
	Total	Male	Female	Total	Male	Female
0- 5	65.69	59.70	69.83	63.35	59.12	66.29
5-10	61.56	56.87	64.83	59.45	55.91	61.79
10-15	56.98	52.72	59.83	54.88	51.39	57.19
15-20	53.88	49.23	57.20	50.07	46.39	52.53
20-25	49.22	44.64	52.49	45.15	41.59	47.53
25-30	44.49	40.17	47.60	40.45	37.29	42.58
30-35	40.00	35.72	43.09	35.98	33.25	37.80
35-40	35.83	32.02	38.60	31.78	29.34	33.41
40-45	32.29	28.95	34.76	28.28	26.59	29.42
45-50	29.02	26.55	30.92	25.00	23.75	25.85
50-55	24.65	22.27	26.44	20.69	19.52	21.46
55-60	20.67	18.40	22.31	16.98	15.89	17.67
60-65	17.33	15.02	18.94	14.07	13.00	14.69
65-70	14.97	12.50	16.61	12.32	11.07	13.01
70-75	12.05	10.01	13.34	10.04	8.95	10.61
75-80	9.66	7.65	10.91	8.66	7.74	9.12
80-85	8.10	6.05	9.30			
85-90	7.50	5.31	8.66			
90-	7.54	6.23	8.17			

SOURCE: Bale, GS, and PS Entmacher. Expected life expectancy of diabetics. Diabetes 26:434-38, 1977.

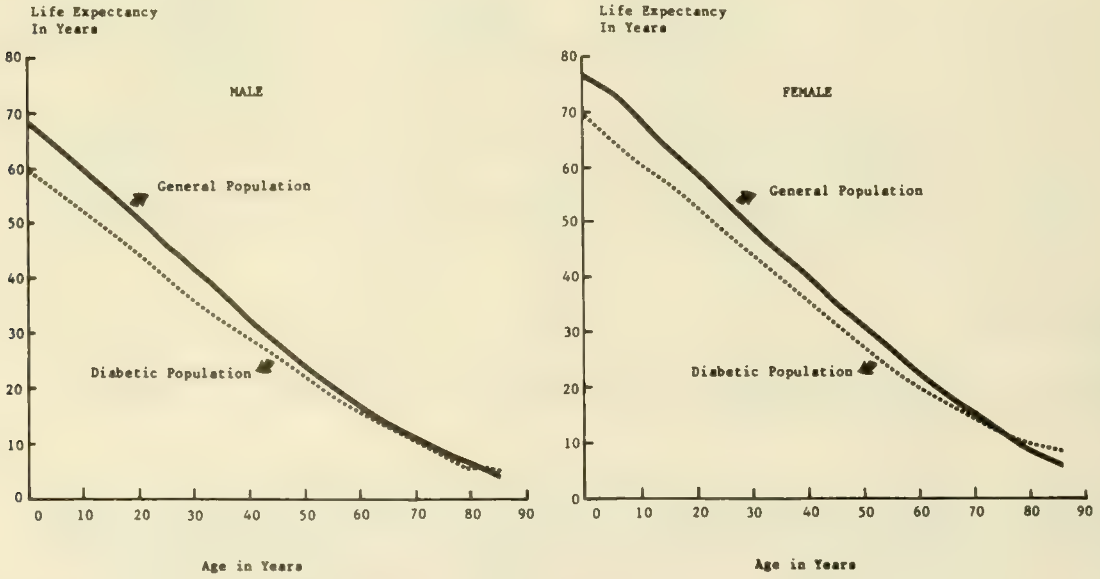

FIGURE 2. *Life expectancy by sex, diabetic population of Iowa, 1972-73, versus general population of Iowa, 1969-71*

SOURCE: Bale, GS, and PS Entmacher. Expected life expectancy of diabetics. Diabetes 26:434-38, 1977.

In 1978, the most recent year for which diabetes multiple cause of death data are available, almost half (46 percent) of deaths on diabetes death certificates occurred at ages 75 years and older, compared to 44 percent for all deaths recorded on certificates in 1978 (Table 19). The proportion occurring at age 75 years and older varied from only about one-fourth for black male diabetics to over one-half for white female diabetics. About 14 percent of diabetes deaths occurred at ages 85 and older, compared to 17 percent of deaths in the United States as a whole (Table 19).

TABLE 19. *Percent of diabetes deaths and all deaths occurring at certain ages or older, United States, 1978*

Age at Death (Years)	Diabetes, Underlying and Contributing Causes					All Causes of Death, All Persons*
	WM	WF	BM	BF	All	
25+	99.7	99.8	99.4	99.6	99.8	96.3
45+	97.2	98.3	92.3	95.8	97.5	91.8
55+	91.0	94.8	79.7	86.4	92.1	83.3
65+	72.4	82.8	55.4	64.8	76.2	67.7
75+	39.8	55.4	23.6	32.3	46.0	43.7
85+	10.7	18.7	5.4	8.1	14.1	17.2

*Excludes deaths occurring under one year of age.

SOURCE: Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed with the Division of Vital Statistics, National Center for Health Statistics; and Final Mortality Statistics 1978. DHHS Pub. No. (PHS) 80-1120, September 17, 1980.

SPECIAL ANALYSES OF DIABETES AS THE UNDERLYING CAUSE OF DEATH ON DEATH CERTIFICATES

Time Trends in the Death Rate from Diabetes as the Underlying Cause of Death

Throughout the past 30 years, nonwhites have consistently exhibited higher diabetes death rates (number of diabetes underlying cause deaths per 100,000 living population) compared to whites of the same sex, and females have exhibited higher rates than males of the same race (Figure 3). Significant changes have occurred in the pattern of mortality from diabetes as an underlying cause of death (Figures 3 and 4). Although the rates rose throughout the first half of this century, and also during the 1950s and 1960s, there has been a major decline in the rates for each race/sex group in the past decade (Figure 3). From 1970 to 1980, the diabetes underlying cause death rate fell 18.5 percent. Because of the strong association between cardiovascular diseases and diabetes on death certificates (Tables 10-12), it has been postulated that this decline is due to a decrease in cardiovascular deaths among diabetics (Harris 1980). The death rate from all causes in the United States has also exhibited a major decline during the past decade, which is believed to be due to a decrease in cardiovascular disease deaths (Havlik and Feinleib 1979).

Time trends in the death rate (number of deaths per 100,000 living persons) are influenced by the changing age structure of the United States population. "Age-adjustment" corrects for this by using a standard population with a specific age composition for all years being compared. (The United States population structure of 1940 is often the standard.) In this manner, an increase over time in the number of older persons, and their ensuing increased contribution to rate of death relative to the contribution

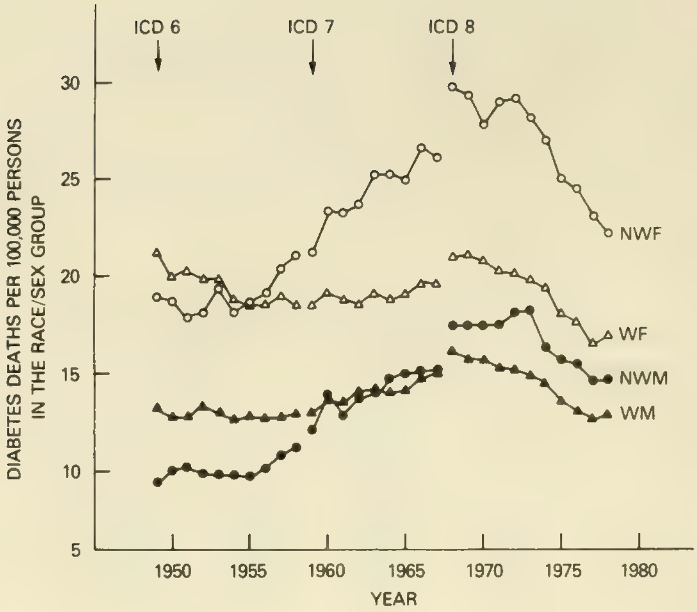

FIGURE 3. *Race/sex-specific death rate trends for diabetes as the underlying cause of death, United States, 1949-78. W=white, NW=nonwhite, M=male, F=female.*

SOURCE: United States death certificate data collected by the Division of Vital Statistics, National Center for Health Statistics.

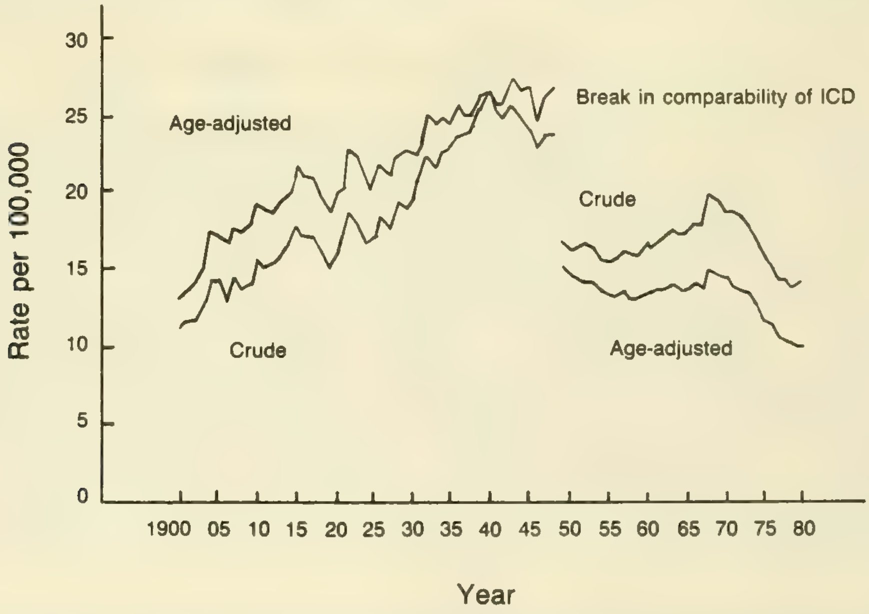

FIGURE 4. *Trends in the underlying cause death rate from diabetes per 100,000 population (crude) and age-adjusted death rate (based on age distribution of the 1940 population), United States, 1900-80*

SOURCE: Death certificate data, death registration States (1900-32) and all States (1933-80), Metropolitan Life Insurance Company, Statistical Bureau.

of younger age groups, is statistically counteracted. Age-adjusted rates are more informative in assessing time trends in mortality because the influence of changing age structure has been removed, and any trend in these rates may indicate a real change in factors influencing diabetes mortality.

Geographic Variations in Mortality from Diabetes as the Underlying Cause of Death

Region and State. Diabetes underlying cause mortality is characterized by considerable variation from one area of the United States to another. Table 20 presents underlying cause death rates due to diabetes for the nine geographic divisions of the country and for each State in 1977. Mortality was highest in Rhode Island, followed by Louisiana, Delaware, Indiana, Ohio, Pennsylvania and New York—all with death rates of 18.0 or higher per 100,000 living population. The lowest rates were reported in Colorado, Hawaii, California, Arizona, Oregon, Minnesota, New Mexico, and Montana.

TABLE 20. *Diabetes underlying cause death rates per 100,000 population by region and State, United States, 1977*

Region and State	Rate
United States	15.0
New England	16.0
Middle Atlantic	17.0
East North Central	17.0
West North Central	15.4
South Atlantic	14.9
East South Central	15.4
West South Central	13.9
Mountain	11.1
Pacific	10.3
New England	
Maine	13.2
New Hampshire	17.4
Vermont	13.2
Massachusetts	16.8
Rhode Island	19.4
Connecticut	14.3
Middle Atlantic	
New York	18.0
New Jersey	17.3
Pennsylvania	18.1
East North Central	
Ohio	18.2
Indiana	18.5
Illinois	15.4
Michigan	17.6
Wisconsin	15.2
West North Central	
Minnesota	11.3
Iowa	16.1
Missouri	17.9
North Dakota	14.9
South Dakota	16.1
Nebraska	13.7
Kansas	17.1
South Atlantic	
Delaware	18.7
Maryland	14.9
District of Columbia	17.6
Virginia	12.1
West Virginia	17.4
North Carolina	14.6
South Carolina	15.9
Georgia	13.8
Florida	15.9
East South Central	
Kentucky	17.2
Tennessee	12.7
Alabama	16.9
Mississippi	15.2
West South Central	
Arkansas	14.0
Louisiana	18.8
Oklahoma	14.3
Texas	12.2
Mountain	
Montana	11.5
Idaho	12.9
Wyoming	12.6
Colorado	9.2
New Mexico	11.3
Arizona	11.0
Utah	12.6
Nevada	12.1
Pacific	
Alaska	2.3
California	10.0
Hawaii	9.5
Oregon	11.2
Washington	12.4

SOURCE: Statistical Bureau of the Metropolitan Life Insurance Company. Based on data from the Division of Vital Statistics, National Center for Health Statistics.

Mortality rates in these States were less than 12.0 per 100,000 living population and were one-third lower than rates in the highest seven States. These differences may be attributable to differences in age distribution of the population in various States. Racial distribution may also have an important impact, since in all States, except Alaska, the rates for nonwhites exceed those of the white population. The low rate for nonwhites in Alaska probably results from the rarity of diabetes among Eskimos and Aleuts, who make up the majority of this State's nonwhite population.

Urban versus rural. A comparison of mortality differences between the population residing in metropolitan counties in the United States with that dwelling in nonmetropolitan counties is shown in Table 21. The data indicate that diabetes mortality is consistently lower in metropolitan areas. Table 22 shows the death rate for diabetes in various cities in the United States.

TABLE 21. *Death rates per 100,000 population for diabetes as the underlying cause of death in metropolitan and nonmetropolitan counties, United States, 1969-71*

Race and Sex	Metropolitan	Nonmetropolitan
Total persons	17.7	21.5
White males	14.5	17.9
White females	19.7	23.1
Nonwhite males	15.9	21.6
Nonwhite females	25.9	36.9

SOURCE: Statistical Bureau of the Metropolitan Life Insurance Company. Based on data from the Division of Vital Statistics, National Center for Health Statistics.

State economic areas. Figures 5 to 8 illustrate the age-adjusted rates of mortality from diabetes as the underlying cause of death for white males, white females, nonwhite males, and nonwhite females for each of the 506 State economic areas (SEA) in the United States in 1968-71 (Mason et al. 1981). Many SEA's are concordant for race/sex-specific diabetes death rates that are not significantly different from the United States race/sex-specific diabetes death rates. However, the maps also show geographic variations in diabetes mortality rates by race and sex. High rates for white females occurred across a broad band including New Jersey, Pennsylvania, Ohio, Michigan, and Wisconsin; white females also showed high rates in Utah, Kansas, the Rio Grande valley in Texas, and the Mississippi River delta in Louisiana. Significantly low rates occurred in the far west and Florida. The pattern for white males was similar except that the northern band was not as well defined. The high rates in Kansas, Texas, and Louisiana also occurred, as did low rates in the west and Florida, but the other high rate areas were absent. Since the category "whites" includes Hispanics, it is likely that the clustering of high mortality rates in the Rio Grande valley can be attributed to the Mexican-American population in this area. The prevalence of diabetes in this group is believed to be significantly higher than for other whites (Stern et al. 1981).

TABLE 22. *Death rates for diabetes in standard metropolitan statistical areas with populations of 500,000 or more, by region, United States, 1969-71*

SMSA's of 1,000,000 or Over	Death Rate Per 100,000	SMSA's of 500,000 to 999,999	Death Rate Per 100,000
North		North	
Boston, MA	23.6	Albany-Schenectady-Troy, NY	23.7
Buffalo, NY	19.1	Allentown-Bethlehem-Easton, PA-NJ	21.3
Newark, NJ	22.9		
New York, NY	21.6	Hartford, CT	20.3
Patterson-Clifton-Passaic, NJ	18.9	Jersey City, NJ	32.1
Philadelphia, PA-NJ	20.6	Providence-Pawtucket-Warwick, RI-MA	26.3
Pittsburgh, PA	22.9		
		Rochester, NY	14.2
South		Springfield-Chicopee-Holyoke, MA-CT	20.6
Atlanta,GA	13.8		
Baltimore, MD	26.6	Syracuse, NY	16.1
Dallas, TX	12.1		
Houston, TX	11.4	South	
Miami, FL	19.5	Birmingham, AL	19.8
New Orleans, LA	31.3	Fort Lauderdale-Hollywood, FL	18.0
Tampa-St. Petersburg, FL	20.7	Fort Worth, TX	13.3
Washington, DC-MD-VA	12.9	Greensboro-Winston-Salem-High Point, NC	12.5
North Central		Jacksonville, FL	16.3
Chicago, IL	17.4	Louisville, KY-IN	20.9
Cincinnati, OH-KY-IN	18.9	Memphis, TN-AR	14.4
Cleveland, OH	21.5	Nashville-Davidson, TN	10.9
Detroit, MI	24.9	Norfolk-Portsmouth, VA	11.1
Indianapolis, IN	17.4	Oklahoma City, OK	13.3
Kansas City, MO-KS	17.1	Richmond, VA	15.6
Milwaukee, WI	18.1	San Antonio, TX	20.7
Minneapolis-St. Paul, MN	12.5		
St. Louis, MO-IL	22.2	North Central	
		Akron, OH	17.5
West		Columbus, OH	18.8
Anaheim-Santa Ana-Garden Grove, CA	4.5	Dayton, OH	18.0
Denver, CO	9.4	Gary-Hammond-East Chicago, IN	20.4
Los Angeles-Long Beach, CA	15.1	Grand Rapids,MI	16.9
Portland, OR-WA	13.3	Omaha, NE-IA	14.9
San Bernardino-Riverside-Ontario, CA	12.1	Toledo, OH-MI	23.1
		Youngstown-Warren, OH	24.1
San Diego, CA	9.0		
San Francisco-Oakland, CA	12.2	West	
San Jose, CA	10.0	Honolulu, HI	12.3
Seattle-Everett, WA	14.3	Phoenix, AZ	13.2
		Sacramento, CA	12.2
		Salt Lake City, UT	14.8

SOURCE: Statistical Bureau of the Metropolitan Life Insurance Company. Based on data from the Division of Vital Statistics, National Center for Health Statistics.

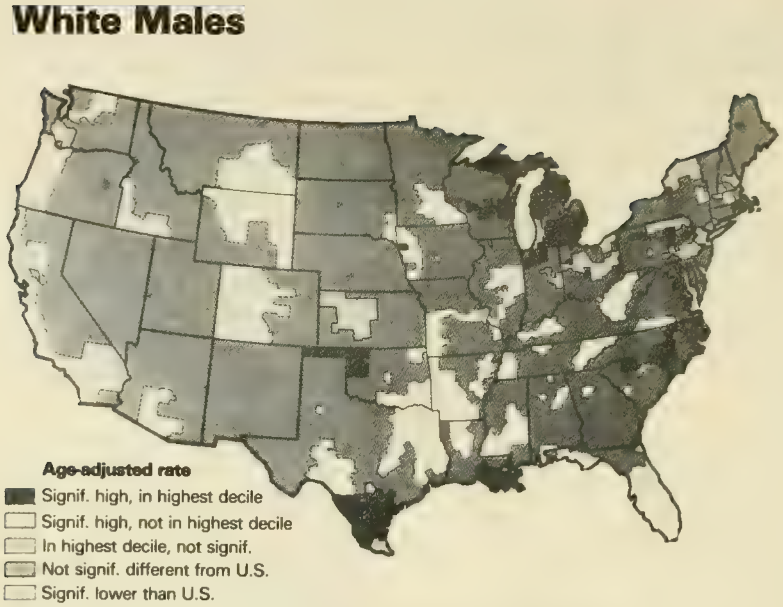
White Males
Age-adjusted rate
Signif. high, in highest decile
Signif. high, not in highest decile
In highest decile, not signif.
Not signif. different from U.S.
Signif. lower than U.S.

FIGURE 5. *Age-adjusted diabetes death rate for white males, United States, 1968-71. The number of WM deaths occurring during this period was 54,333. The United States age-adjusted WM death rate was 15.97 per 100,000 population; the 90th percentile rate was 21.92.*

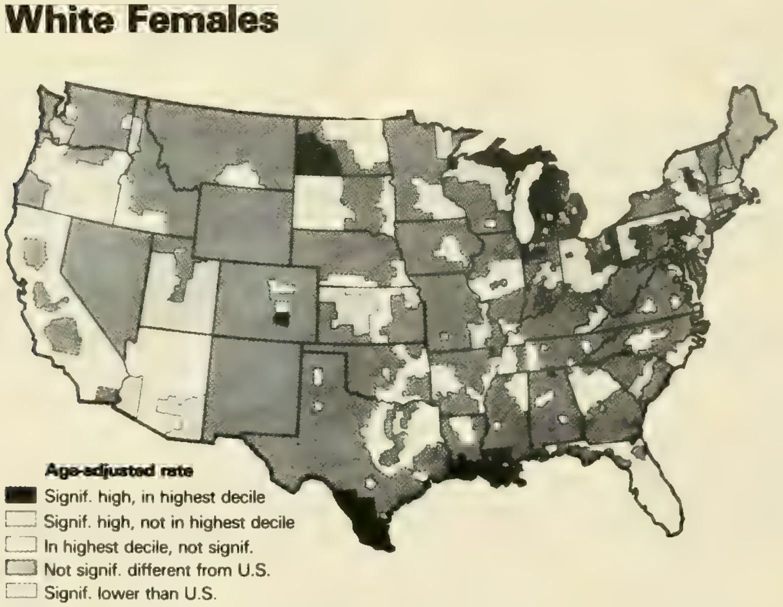
White Females
Age-adjusted rate
Signif. high, in highest decile
Signif. high, not in highest decile
In highest decile, not signif.
Not signif. different from U.S.
Signif. lower than U.S.

FIGURE 6. *Age-adjusted diabetes death rate for white females, United States, 1968-71. The number of WF deaths occurring during this period was 75,378. The United States age-adjusted WF death rate was 16.36 per 100,000 population; the 90th percentile rate was 23.83.*

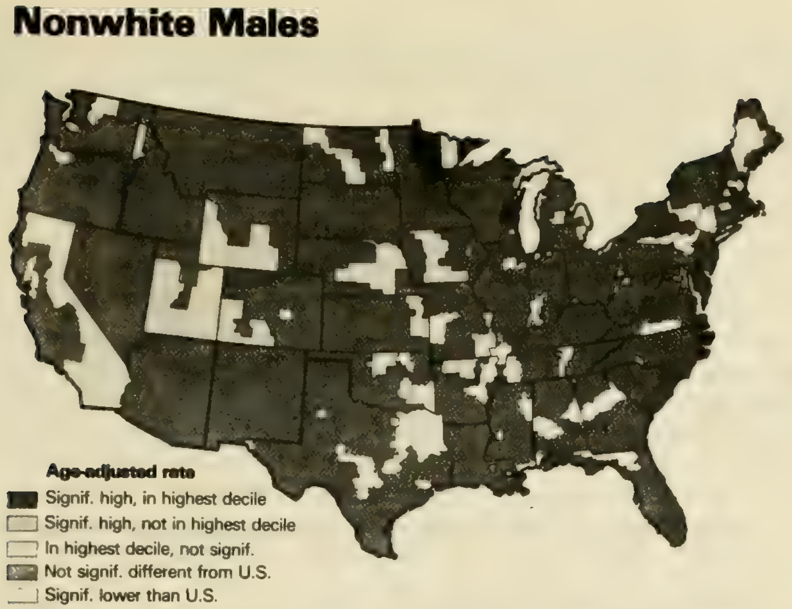
Nonwhite Males
Age-adjusted rate
Signif. high, in highest decile
Signif. high, not in highest decile
In highest decile, not signif.
Not signif. different from U.S.
Signif. lower than U.S.

FIGURE 7. *Age-adjusted diabetes death rate for nonwhite males, United States, 1968-71. The number of NWM deaths occurring during this period was 8,230. The United States age-adjusted NWM death rate was 23.73 per 100,000 population; the 90th percentile rate was 44.96.*

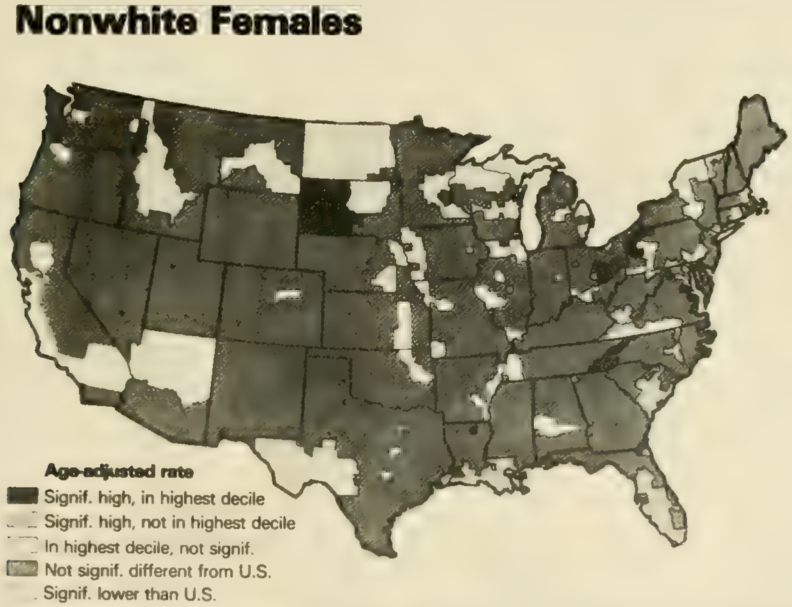
Nonwhite Females
Age-adjusted rate
Signif. high, in highest decile
Signif. high, not in highest decile
In highest decile, not signif.
Not signif. different from U.S.
Signif. lower than U.S.

FIGURE 8. *Age-adjusted diabetes death rate for nonwhite females, United States, 1968-71. The number of NWF deaths occurring during this period was 15,028. The United States age-adjusted NWF death rate was 36.17 per 100,000 population; the 90th percentile rate was 67.03.*

For nonwhite (blacks, American Indians, Asian Americans) males and females, no consistent pattern was seen. The northeast band was absent for both sexes, and pockets of high rates were scattered, with some concentration in the east for nonwhite females. The Mississippi River delta "hot spot" was present for females but not for males. High rates were found in Florida for females, but not males; and in Minnesota and Maine for males, but not for females. The low rates in California for whites of both sexes were also present for nonwhites of both sexes.

Variation in the presence of other diseases that precipitate death might account for these geographic patterns. Cardiovascular diseases are the leading contributing causes of death on diabetes death certificates for all four race/sex groups (Tables 10 and 11), but mortality maps where cardiovascular diseases were the underlying cause of death in 1968-71 show little similarity to diabetes mortality patterns (Fabsitz and Feinleib 1980).

Seasonal Variation in Mortality from Diabetes as the Underlying Cause of Death

Mortality from diabetes has a seasonal pattern, in that deaths from diabetes as the underlying cause of death are more frequently reported in the winter months and are least prevalent in the summer months (Table 23). The seasonality of diabetes mortality might be attributed to diabetes deaths being linked to cardiovascular-renal disease deaths which exhibit a seasonal pattern comparable to that of diabetes as the underlying cause of death. A similar, although more marked, seasonal pattern of deaths occurs for influenza and pneumonia, although on death certificates only 7 percent percent of diabetes deaths were attributed to these causes (Harris 1983).

TABLE 23. *Seasonal variation in mortality from diabetes as the underlying cause of death: Death rate in each month as percent of annual death rate, United States, 1959-78*

Month	1978	1977	1969-71	1959-61
All months	100.0	100.0	100.0	100.0
January	122.2	113.7	113.8	108.9
February	111.7	108.2	109.2	110.0
March	105.9	107.1	104.0	103.7
April	97.9	103.5	100.3	100.6
May	96.9	99.1	98.2	99.0
June	92.5	97.4	96.9	97.5
July	96.3	97.1	95.9	94.0
August	90.9	88.9	91.7	91.6
September	91.3	88.7	89.5	90.9
October	96.4	92.4	94.4	97.0
November	95.7	95.5	101.3	98.6
December	102.5	108.6	105.3	108.6

SOURCE: Statistical Bureau of the Metropolitan Life Insurance Company. Based on data from the Division of Vital Statistics, National Center for Health Statistics.

Standardized Mortality Ratios (SMR)

A method of comparing mortality among diabetics to that of the general population is to compute the ratio of the number of deaths among diabetics to the expected number of deaths in the general population. Based on diabetes patients first seen at the Joslin Clinic between 1930 and 1956 that were studied until 1960, the Standardized Mortality

Ratio (SMR) was 1.66 for males and 2.18 for females, with the highest ratios found in men between 20 and 39 years of age and in women ages 30-39. Among male employees of the Dupont Company, the ratio of actual to expected deaths was 2.62, with the highest ratios among those under 45 years of age (Pell and D'Alonzo 1967). In the adult population of Framingham, Massachusetts, the SMR for diabetics was 2.80 (Garcia et al. 1974).

Among 1,047 black diabetics in Memphis and Atlanta, there was an excess number of deaths compared to the number of deaths expected for an age/sex/race-matched United States population (Vander Zwaag et al. 1983). During the 9-year study, there were 404 deaths. For diabetics treated with insulin, there were 62 percent excess deaths (SMR = 1.62); for diabetics not treated with insulin, the excess was 33 percent (SMR = 1.33). The excess increased with increasing duration of diabetes, being 25 percent at 0-10 years duration, 57 percent at 10-14 years duration, and 91 percent at 10 years or greater duration of diabetes. The excess was greater among younger diabetics, being 123 percent among persons age less than 44 years at entry into the study, 70 percent among ages 45 to 64, and 20 percent among ages 65 and older.

Autopsy of Deaths from Diabetes as the Underlying Cause of Death

Autopsy data can be used to determine the cause of death. However, of death certificates in 1979 naming diabetes as the underlying cause of death, in only 7.4 percent was it reported that an autopsy was performed (Table 24). For all deaths in the United States, an autopsy was performed in twice as many deaths (15.4 percent).

TABLE 24. *Number of autopsies and percent of deaths for which autopsies were reported for the 15 leading causes of death, United States, 1979*

Rank	Underlying Cause of Death	ICD Number	Total Deaths	Reported Autopsies	
				Number	Percent
-	All causes		1,913,841	294,182	15.4
1	Diseases of the heart	390-398,402,404-429	733,235	73,148	10.0
2	Malignant neoplasms	140-208	403,395	38,034	9.4
3	Cerebrovascular diseases	430-438	169,488	9,771	5.8
4	Accidents and adverse effects	E800-E949	105,312	44,873	42.6
	Motor vehicle accidents	E810-E825	53,524	22,632	42.3
	All other accidents and adverse effects	E800-E807,E826-E949	51,788	22,241	42.9
5	Chronic obstructive pulmonary diseases and allied conditions	490-496	49,933	4,947	9.9
6	Pneumonia and influenza	480-487	45,030	7,873	17.5
7	Diabetes mellitus	250	33,192	2,457	7.4
8	Chronic liver disease and cirrhosis	571	29,720	8,482	28.5
9	Atherosclerosis	440	28,801	1,052	3.7
10	Suicide	E950-E959	27,206	12,300	45.2
11	Certain conditions originating in the perinatal period	760-779	23,448	8,078	34.5
12	Homicide and legal intervention	E960-E978	22,550	21,019	93.2
13	Nephritis, nephrotic syndrome, and nephrosis	580-589	15,729	1,859	11.8
14	Congenital anomalies	740-759	13,526	6,577	48.6
15	Septicemia	038	8,024	1,599	19.9
-	All other causes	Residual	205,252	52,113	25.4

SOURCE: National Center for Health Statistics. Monthly Vital Statistics Report, Vol. 31, No. 6, September 30, 1982.

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APPENDIX A. *Population of the United States, by age, sex, and race, 1980*

Age (Years), Sex, Race	Thousands of Persons
All persons	226,505
Under 25	93,756
25-34	37,075
35-44	25,631
45-54	22,797
55-64	21,700
65-74	15,578
75-84	7,727
85+	2,240
White males	91,670
Under 25	37,886
25-34	15,303
35-44	10,679
45-54	9,556
55-64	9,025
65-74	6,033
75-84	2,573
85+	614
White females	96,671
Under 25	36,477
25-34	15,322
35-44	10,905
45-54	10,056
55-64	10,186
65-74	7,872
75-84	4,421
85+	1,430

Age (Years), Sex, Race	Thousands of Persons
Black males	12,516
Under 25	6,615
25-34	1,955
35-44	1,228
45-54	1,019
55-64	851
65-74	565
75-84	227
85+	53
Black females	13,972
Under 25	6,691
25-34	2,254
35-44	1,480
45-54	1,251
55-64	1,056
65-74	774
75-84	359
85+	106
Asian and Pacific Islander	3,500
Males	1,693
Females	1,807
American Indian, Eskimo, Aleut	1,418
Males	701
Females	717
Other	6,757
Males	3,452
Females	3,405
Spanish origin	14,605
Males	7,278
Females	7,327

SOURCE: Bureau of the Census, U.S. Department of Commerce, 1980 Census of the Population, Supplementary Report, May 1981.

APPENDIX B. *Number of deaths from diabetes (ICD 250) as underlying cause of death, by 5-year age groups, race, and sex, United States, 1980*

Race and Sex	Age (Years) All	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39
All	34,851	4	12	15	22	33	95	244	328	415
Male	14,325	2	7	8	13	15	48	118	201	243
Female	20,526	2	5	7	9	18	47	126	127	172
White	28,868	2	7	13	15	26	70	186	266	307
Male	12,125	1	2	6	10	10	36	93	167	180
Female	16,743	1	5	7	5	16	34	93	99	127
All other	5,983	2	5	2	7	7	25	58	62	108
Male	2,200	1	5	2	3	5	12	25	34	63
Female	3,783	1	-	-	4	2	13	33	28	45
Black	5,544	1	5	2	7	7	24	52	61	106
Male	2,010	-	5	2	3	5	11	21	34	62
Female	3,534	1	-	-	4	2	13	31	27	44

	Age (Years) 40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+	Unknown
All	485	773	1,415	2,364	3,425	4,655	5,456	5,484	4,650	4,971	5
Male	263	386	708	1,162	1,589	2,037	2,279	2,133	1,631	1,481	1
Female	222	387	707	1,202	1,836	2,618	3,177	3,351	3,019	3,490	4
White	349	552	1,042	1,772	2,676	3,699	4,566	4,697	4,124	4,498	1
Male	193	290	563	902	1,315	1,709	1,973	1,848	1,466	1,361	-
Female	156	262	479	870	1,361	1,990	2,593	2,849	2,658	3,137	1
All other	136	221	373	592	749	956	890	787	526	473	4
Male	70	96	145	260	274	328	306	285	165	120	1
Female	66	125	228	332	475	628	584	502	361	353	3
Black	121	201	343	546	682	889	831	733	488	441	4
Male	58	85	131	239	250	301	276	262	153	111	1
Female	63	116	212	307	432	588	555	471	335	330	3

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

APPENDIX C. *Age-specific death rates per 100,000 population for diabetes (ICD 250) as the underlying cause of death, by 5-year age groups, race, and sex, United States, 1980*

Race and Sex	Age (Years)									
	All	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39
All	15.4	0.1	0.1	0.1	0.1	0.2	0.4	1.2	1.9	3.0
Male	13.0	0.1	0.1	0.1	0.1	0.1	0.5	1.2	2.3	3.5
Female	17.6	0.1	0.1	0.1	0.1	0.2	0.4	1.3	1.4	2.4
White	14.8	0.1	0.1	0.1	0.1	0.1	0.4	1.1	1.8	2.5
Male	12.8	0.1	0.0	0.1	0.1	0.1	0.4	1.1	2.2	3.0
Female	16.8	0.1	0.1	0.1	0.1	0.2	0.4	1.1	1.3	2.1
All other	18.9	0.3	0.2	0.1	0.2	0.2	0.8	2.0	2.6	5.9
Male	14.6	0.3	0.4	0.1	0.2	0.3	0.8	1.9	3.1	7.5
Female	22.7	0.3	-	-	0.3	0.1	0.8	2.2	2.2	4.5
Black	20.8	0.2	0.3	0.1	0.3	0.2	0.9	2.2	3.2	7.2
Male	16.0	-	0.5	0.2	0.2	0.3	0.8	1.9	3.9	9.3
Female	25.2	0.4	-	-	0.3	0.1	0.9	2.5	2.6	5.5

	Age (Years)									
	40-44	45-59	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
All	4.2	7.0	12.1	20.4	34.0	53.0	80.3	114.4	158.4	221.9
Male	4.6	7.2	12.6	21.2	34.0	52.2	79.9	115.4	160.0	217.3
Female	3.7	6.8	11.6	19.6	33.9	53.7	80.5	113.7	157.6	223.9
White	3.5	5.7	10.1	17.0	29.5	46.9	74.2	107.9	152.4	218.3
Male	3.9	6.1	11.2	18.3	31.2	48.6	76.5	110.8	157.3	219.2
Female	3.0	5.3	9.0	15.9	28.0	45.5	72.5	106.2	149.8	217.9
All other	8.7	15.9	27.7	48.6	74.3	107.5	138.1	178.0	229.5	263.7
Male	9.8	15.2	24.0	47.1	61.1	85.1	111.2	159.1	189.1	197.5
Female	7.9	16.4	30.6	49.8	84.9	124.7	158.2	190.9	254.3	297.5
Black	9.6	17.5	30.3	52.5	78.1	114.2	147.2	189.0	243.8	277.3
Male	10.2	16.4	25.9	51.1	64.8	90.6	117.6	171.3	203.9	209.4
Female	9.2	18.4	33.8	53.7	88.7	131.8	168.3	200.5	267.7	311.2

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

APPENDIX D. *Percent of diabetes underlying cause deaths and all deaths occurring at ages less than 45 years and at age 65 years and older, United States, 1980*

Race and Sex	Under Age 45 Years		Age 65+ Years	
	Diabetes	All Causes	Diabetes	All Causes
All	4.7	11.1	72.4	67.4
All whites	4.3	8.9	74.8	69.8
White males	5.8	12.0	68.9	63.5
White females	3.2	5.1	79.0	77.1
All blacks	7.0	21.0	61.1	50.6
Black males	10.0	24.6	54.9	45.4
Black females	5.3	16.5	64.6	57.3

SOURCE: Harris, MI, National Diabetes Data Group, from data of the Division of Vital Statistics, National Center for Health Statistics.

APPENDIX E. *Time trends in the death rate for all causes and for diabetes as the underlying cause of death, United States: Number of deaths per 100,000 living population*

Year[a]	All Causes of Death	Diabetes as the Underlying Cause of Death						
			Whites		Nonwhites		Blacks	
	All Persons	All Persons	Male	Female	Male	Female	Male	Female
1950	963.8	16.2	12.8	20.0	10.0	18.7		
1955		15.5	12.8	18.5	9.7	18.5		
1960	954.7	16.7	13.7	19.1	13.9	23.4		
1965		17.1	14.2	19.1	15.0	25.0		
1970	945.3	18.9	15.7	20.8	17.5	27.9		
1971	932.0	18.6	15.3	20.3	17.5	29.1		
1972	938.4	18.6	15.2	20.2	18.1	29.2		
1973	933.5	18.2	14.9	19.9	18.2	28.2		
1974	906.7	17.7	14.5	19.5	16.3	27.1		
1975	878.5	16.5	13.6	18.1	15.7	25.1		
1976	877.6	16.1	13.1	17.7	15.5	24.5		
1977	864.4	15.2	12.7	16.5	14.6	23.1		
1978	868.0	15.5	12.9	17.0	14.7[b]	22.5[b]		
1979	869.5	15.1	12.6	16.4	14.7	21.9	15.6	24.0
1980	878.3	15.4	12.8	16.8	14.6	22.7	16.0	25.2
1981	862.4	15.1	12.6	16.6	13.8	21.9	15.0	24.7
1982	852.0	14.9	12.5	16.6	13.0	20.4	14.4	23.0

[a] Years before 1950 are not shown because of lack of comparability with years since 1950 in selecting diabetes as the cause of death using international coding rules.

[b] In 1978, 90 percent of nonwhite male diabetic deaths were deaths in black males; 94 percent of nonwhite female diabetic deaths were deaths in black females.

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

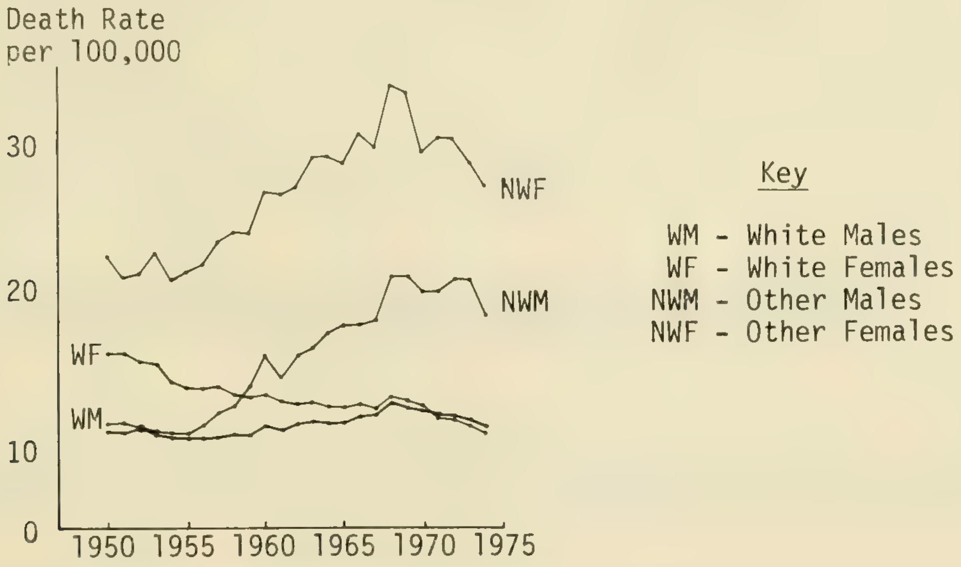
APPENDIX F. *Age-adjusted death rates per 100,000 population for diabetes as the underlying cause of death on death certificates, United States, 1960-82**

Year	All	WM	WF	NWM	NWF	ALL M	ALL F	ALL W	ALL NW
1982	9.6	9.2	8.3	14.7	18.1	9.8	9.3	8.7	16.7
1981	9.8	9.3	8.4	15.6	19.5	10.0	9.6	8.8	17.9
1980	10.1	9.5	8.7	16.4	20.6	10.2	10.0	9.1	18.8
1979	10.0	9.5	8.6	16.2	20.3	10.2	9.8	9.0	18.5
78	10.4	9.8	9.1	16.3	21.0	10.5	10.3	9.4	19.0
77	10.4	9.8	9.0	16.3	22.0	10.5	10.3	9.4	19.5
76	11.1	10.2	9.7	17.5	23.7	10.9	11.1	10.0	21.0
1975	11.6	10.7	10.2	17.9	24.6	11.4	11.6	10.4	21.7
74	12.5	11.5	11.2	18.8	27.1	12.2	12.7	11.4	23.4
73	13.2	12.0	11.6	21.1	28.6	12.9	13.3	11.8	25.3
72	13.6	12.3	12.1	21.2	30.1	13.2	13.9	12.2	26.0
71	13.7	12.4	12.3	20.4	30.2	13.2	14.0	12.4	25.7
1970	14.1	12.7	12.8	20.4	29.3	13.5	14.4	12.9	25.2
69	14.4	12.9	13.2	20.4	31.1	13.7	14.9	13.1	26.2
68	14.6	13.3	13.4	20.3	31.7	14.0	15.1	13.4	26.4
67	13.6	12.4	12.7	17.7	28.1	12.9	14.2	12.6	23.2
66	13.7	12.3	12.9	17.7	29.0	12.8	14.4	12.7	23.7
1965	13.4	11.9	12.8	17.5	27.3	12.5	14.2	12.5	22.7
64	13.4	11.8	12.8	17.1	28.0	12.3	14.3	12.4	22.8
63	13.8	11.9	13.3	16.3	28.3	12.4	14.8	12.7	22.6
62	13.4	11.9	13.0	16.0	26.6	12.3	14.4	12.5	21.5
61	13.2	11.4	13.2	14.8	26.5	11.7	14.5	12.4	20.8
1960	13.6	11.6	13.7	16.1	26.8	12.0	15.0	12.8	21.6

*Age-adjusted to the U.S. population of the 1940 census. W = white; NW = nonwhite; M = male; F = female

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

APPENDIX G. *Age-adjusted death rates for diabetes mellitus, by color and sex, United States, 1950-74*



SOURCE: Report of the National Commission on Diabetes, Vol. III, Part 1, DHEW Pub. No. (NIH) 76-1021.

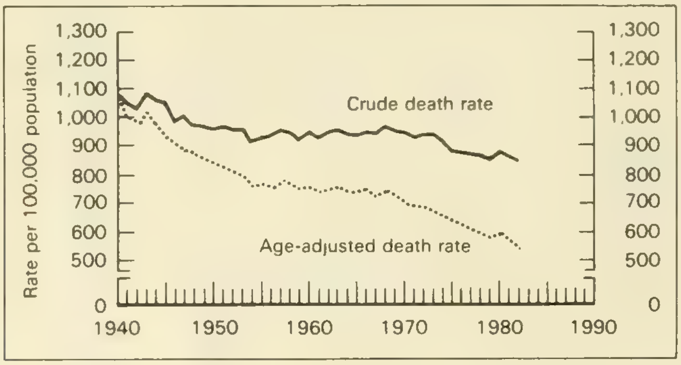
APPENDIX H. *Declines in the death rate and age-adjusted death rate from diabetes as the underlying cause of death, by race and sex, United States, 1970-80*

Race and Sex	1970	1980	Percent Change
	Diabetes Deaths/100,000 Population		
All	18.9	15.4	-18.5%
White males	15.7	12.8	-18.5
White females	20.8	16.8	-19.2
Nonwhite males	17.5	14.6	-16.6
Nonwhite females	27.9	22.7	-18.6
	Age-Adjusted* Diabetes Death Rate/100,000 Population		
All	14.1	9.9	-29.8%
White males	12.7	9.4	-26.0
White females	12.8	8.7	-32.0
Nonwhite males	20.4	13.8	-32.4
Nonwhite females	29.3	17.3	-40.9

*Age-adjusted to the United States population structure of 1940

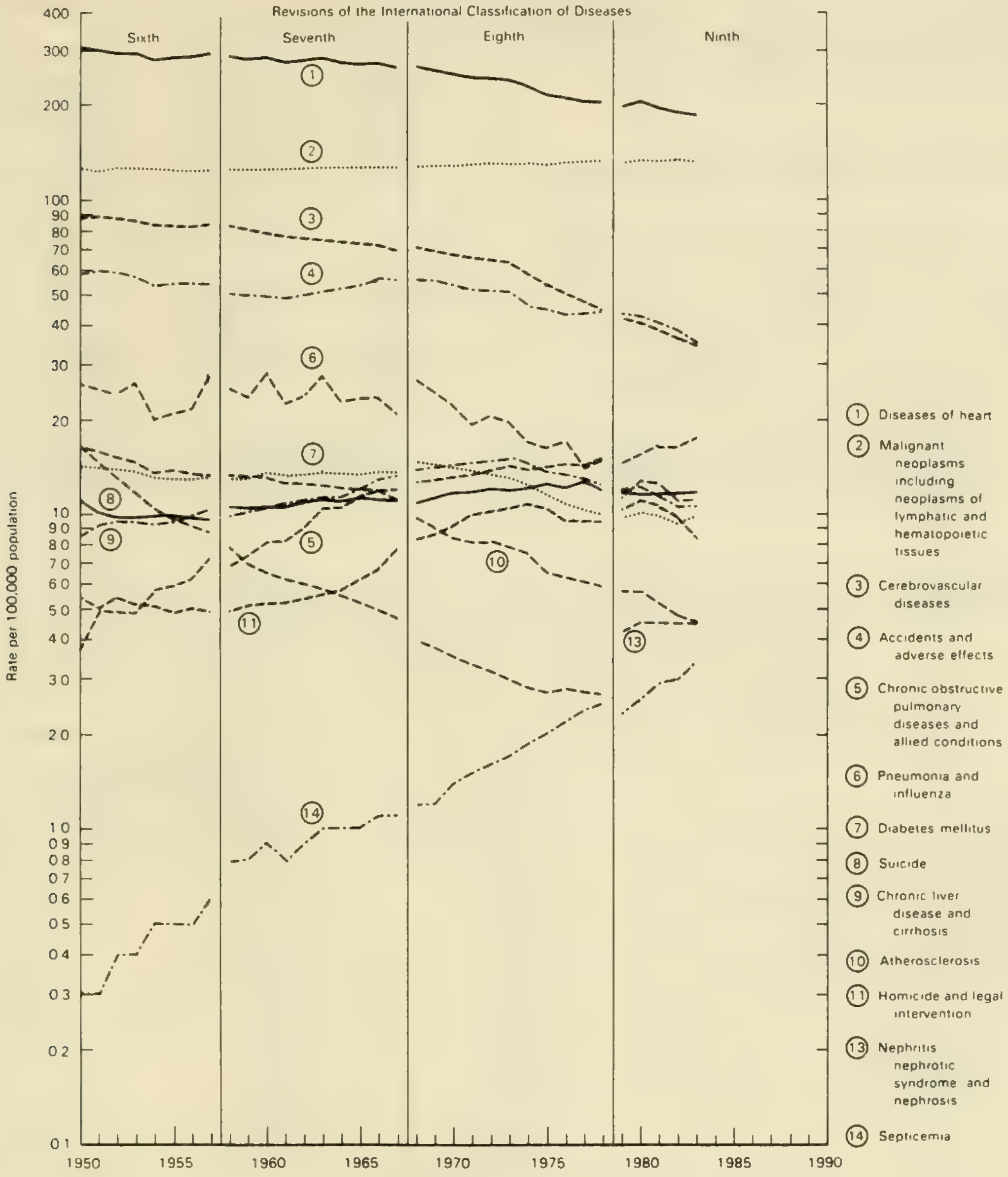
SOURCE: Harris, MI, National Diabetes Data Group, from death certificate data filed with the Division of Vital Statistics, National Center for Health Statistics.

APPENDIX I. *Crude and age-adjusted death rates from all causes of death, United States, 1940-82*



SOURCE: Division of Vital Statistics, National Center for Health Statistics. Monthly Vital Statistics Report, Vol. 33, No. 9, Supplement. December 20, 1984.

APPENDIX J. *Age-adjusted death rates for the 13 leading causes of death, United States, 1950-83*



SOURCE: Division of Vital Statistics, National Center for Health Statistics. Monthly Vital Statistics Report, Vol. 32, No. 13. September 21, 1984.

APPENDIX K. *Characteristics of death certificates in which diabetes was the underlying cause of death, United States, 1978*

Underlying Cause of Death	Age at Death (Years)			
	All	0-34	35-64	65+
Diabetes With Acidosis or Coma, ICD 250.0				
Number of certificates	2,848	247	1,172	1,669
Number (and %) with no other condition	431 (15.1%)	79 (32.0%)	155 (13.2%)	197 (11.8%)
Number of other listed conditions	4,463	229	1,443	2,787
Average number of other listed conditions	1.57	0.93	1.23	1.67
Diabetes Without Acidosis or Coma, ICD 250.9				
Number of certificates	30,993	508	7,778	22,705
Number (and %) with no other condition	469 (1.5%)	46 (9.1%)	152 (2.0%)	271 (1.2%)
Number of other listed conditions	73,384	1,037	17,872	54,475
Average number of other listed conditions	2.37	2.04	2.30	2.40

SOURCE: Harris, MI, National Diabetes Data Group, from multiple cause of death data on death certificates filed with the Division of Vital Statistics, National Center for Health Statistics.

APPENDIX L. *Causes of death on 33,841 certificates with diabetes as the underlying cause of death* and 96,847 certificates with diabetes as a contributing cause of death**, United States, 1978*

Condition	Number of Mentions	Percent Distribution	
		Including Diabetes	Excluding Diabetes
Ketoacidosis/coma	5,226	1.7	-
All circulatory system diseases	121,458	40.2	72.3
Ischemic heart disease	73,320	24.3	43.6
Cerebrovascular disease	21,106	7.0	12.6
All other circulatory diseases	27,070	9.0	16.1
Neoplasms	11,913	3.9	7.1
Infections, pneumonia, influenza	8,363	2.8	5.0
Renal diseases, uremia	10,091	3.3	6.0
Diabetes without ketoacidosis/coma	128,688	42.6	-
All other conditions	16,256	5.4	9.7
Total	301,995	100.0	100.0

*All causes on the certificate are included in the table.

**Only the underlying cause is included in the table.

SOURCE: Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

APPENDIX M. *Diabetes as a contributing cause of death: Number and percent distribution of death certificates listing diabetes as a contributing cause of death, United States, 1978*

Underlying Cause of Death	ICD Number	Age at Death (Years)							
		All Ages		0-34		35-64		65+	
		Number	%	Number	%	Number	%	Number	%
Infections and parasitic diseases	000-136	980	1.0	28	6.2	322	1.5	629	0.8
Neoplasms (benign and malignant)	140-239	10,698	11.1	21	4.6	2,612	12.3	8,062	10.7
Endocrine, nutritional, metabolic diseases	240-279	464	0.5	25	5.5	176	0.8	263	0.4
Blood diseases	280-289	216	0.2	6	1.3	47	0.2	163	0.2
Mental system diseases	290-315	278	0.3	5	1.0	131	0.6	142	0.2
Nervous system diseases	320-389	526	0.5	28	6.2	152	0.7	346	0.5
Circulatory system dis.	390-458	73,183	75.6	151	33.2	15,142	71.4	57,882	77.0
Hypertensive disease	400-404	1,525	1.6	1	0.2	327	1.5	1,196	1.6
Ischemic heart dis.	410-414	52,474	54.2	79	17.4	11,767	55.5	35,423	47.1
Other forms of heart disease	420-429	2,298	2.4	8	1.8	630	3.0	1,660	2.2
Cardiac arrest NOS	427.2	595	0.6	6	1.3	205	1.0	384	0.5
Cerebrovascular dis.	430-438	12,892	13.3	18	4.0	1,727	8.1	11,146	14.8
Dis. of arteries, arterioles, capillaries	440-458	3,472	3.6	4	0.9	579	2.7	2,889	3.8
Respiratory system dis.	460-519	4,675	4.8	65	14.3	847	4.0	3,762	5.0
Digestive system disease	520-577	2,710	2.8	32	7.0	981	4.6	1,697	2.3
Genitourinary system dis.	580-629	1,814	1.9	26	5.7	439	2.1	1,347	1.8
Nephritis/nephrosis	580-584	579	0.6	1	0.2	203	1.0	374	0.5
Other renal diseases	593.2	414	0.4	0	0	121	0.6	293	0.4
Compl. of pregnancy	630-678	1	0.0	1	0	0	0	0	0
Skin/subcutaneous tissue diseases	680-709	57	0.1	0	0	16	0.1	39	0.1
Musculoskeletal/ connective tissue dis.	710-738	220	0.2	5	1.0	70	0.3	145	0.2
Congenital anomalies	740-759	63	0.1	13	2.9	25	0.1	25	0
Perinatal mortality	760-779	3	0.0	3	0.7	0	0	0	0
Symptoms/ill-defined conditions	780-796	3	0.0	0	0	2	0	1	0
Accidents/poisoning/ violence	E800-E999	956	1.0	45	9.9	260	1.2	651	0.9
All listed conditions	000-E999	96,847	100.0	455	100.0	21,221	100.0	75,156	100.0

SOURCE: Harris, MI, National Diabetes Data Group, from multiple causes of death on death certificates filed in 1978 with the Division of Vital Statistics, National Center for Health Statistics.

APPENDIX N. *Conditions most frequently listed as contributing causes of death on diabetes underlying cause death certificates, United States, 1969**

ICD Number	Conditions	Number of Times Listed
412.3	Chronic ischemic heart disease, nonhypertensive	10,917
410.9	Acute myocardial infarction, nonhypertensive	9,136
440.9	Arteriosclerosis (unspecified)	8,544
436.9	Acute cerebrovascular disease without hypertension	3,948
792	Uremia	3,846
427.0	Congestive heart failure	3,144
401	Essential benign hypertension	2,354
412.4	Nonischemic cardiovascular disease, nonhypertensive	2,260
433.9	Cerebral thrombosis without hypertension	2,151
782.4	Acute symptomatic heart failure (unspecified)	1,861
437.9	Ischemic cerebrovascular disease without hypertension	1,696
485	Bronchopneumonia (unspecified)	1,524
445.9	Gangrene (unspecified)	1,503
486	Pneumonia (unspecified)	1,480
427.2	Cardiac arrest (unspecified)	1,394
593.2	Renal disease (unspecified)	1,324
431.9	Cerebral hemorrhage without hypertension	1,285
788.0	Electrolyte disorders	1,264
412.2	Nonischemic cardiovascular disease, hypertensive	1,172
403	Hypertensive renal disease	1,011
514	Pulmonary congestion and hypostasis	890
038.9	Septicemia (unspecified)	882
429.9	Heart disease (unspecified)	777
794	Senility without mention of psychosis	767
450	Pulmonary embolism and infarction	710
796.0	Certain ill-defined conditions	678
590.1	Pyelonephritis, pyelitis, pyelocystitis (unspecified)	630
428	Myocardial insufficiency (unspecified)	630
582	Chronic nephritis	615
344.1	Hemiplegia	552
277	Obesity not specified as of endocrine origin	507
590.0	Chronic pyelonephritis	461
309.9	Mental disorder with physical condition (unspecified)	441
780.0	Coma and stupor	415
782.9	Shock without mention of trauma	406
402	Hypertensive heart disease	405
707.0	Decubitus ulcer	385
285.9	Anemia (unspecified)	349
-	865 Remaining conditions	19,071

*Total number of diabetes underlying cause certificates = 38,541

SOURCE: Pitts, AM. Some notes on U.S. multiple cause of death data. Unpublished manuscript prepared under contract HRA 230-76-0202, October 1976.

APPENDIX O. *Diabetes as a contributing cause of death: Occurrence of diabetes on death certificates for certain underlying causes of death, United States, 1969*

Underlying Cause of Death	Number of Deaths	With Diabetes as an Associated Cause	
		Number (Thousands)	Percent
All causes	1,921,990	91	5
Infectious and parasitic diseases	16,791	1	6
Malignant neoplasms	323,092	9	3
Diabetes mellitus	38,541	2	4*
Hypertensive disease	24,712	2	8
Ischemic heart disease	669,829	51	8
Other heart diseases	53,150	2	4
Cerebrovascular diseases	209,179	15	7
Other circulatory diseases	74,493	4	5
Major respiratory diseases	99,509	4	4
Nephritis and nephrosis	9,417	1	11
Congenital anomalies and infant causes	60,179	0.5	0.8

*In 4 percent of certificates where diabetes was the underlying cause of death, a second diabetes condition (250.0 or 250.9) was also coded.

SOURCE: Pitts, AM. Some notes on U.S. multiple cause of death data. Unpublished manuscript prepared under contract HRA 230-76-0202. October 1976.

APPENDIX P. *The 40 conditions most frequently listed on death certificates, United States, 1969*

Rank	ICD Number	Name of Condition	Total Number Listed
1	412.3	Chronic ischemic heart disease, nonhypertensive	468,443
2	410.9	Acute myocardial infarction, nonhypertensive	387,821
3	440.9	Arteriosclerosis (unspecified)	284,016
4	427.0	Congestive heart failure	137,245
5	250.9	Diabetes mellitus, acidosis or coma unmentioned	132,068
6	436.9	Acute cerebrovasular disease without hypertension	122,825
7	199.0	Multiple malignant neoplasms (sites unspecified)	104,504
8	485	Bronchopneumonia (unspecified)	102,437
9	486	Pneumonia (unspecified)	87,957
10	437.9	Ischemic cerebrovasular disease without hypertension	86,968
11	412.4	Nonischemic cardiovascular disease, nonhypertensive	85,171
12	433.9	Cerebral thrombosis without hypertension	82,308
13	782.4	Acute symptomatic heart failure (unspecified)	78,265
14	427.2	Cardiac arrest (unspecified)	70,105
15	492	Emphysema	67,928
16	162.1	Malignant neoplasm of bronchus and lung	67,027
17	401	Essential benign hypertension	66,501
18	431.9	Cerebral hemorrhage without hypertension	62,697
19	796.0	Certain ill-defined conditions	60,916
20	792	Uremia	60,684
21	514	Pulmonary congestion and hypostasis	49,833
22	450	Pulmonary embolism and infarction	45,569
23	412.2	Nonischemic cardiovascular disease, hypertensive	39,655
24	429.9	Heart disease (unspecified)	37,847
25	777	Immaturity (unqualified)	36,865
26	794	Senility without mention of psychosis	36,664
27	174	Malignant neoplasm of breast	33,555
28	428	Myocardial insufficiency (unspecified)	29,474
29	N854	Intracranial injury (unspecified)	28,725
30	569.9	Disease of intestine and peritoneum (unspecified)	27,292
31	571.9	Cirrhosis of liver (unspecified)	26,339
32	185	Malignant neoplasm of prostate	24,674
33	E930	Complications, misadventures of surgery	23,950
34	153.8	Malignant neoplasm of large intestine (part unspecified)	23,899
35	038.9	Septicemia (unspecified)	23,841
36	573.9	Disease of liver (unspecified)	23,167
37	N998	Complications of surgical procedures (unspecified)	22,626
38	593.2	Renal disease (unspecified)	22,138
39	197.7	Secondary malignant neoplasm of liver	22,127
40	E812	Motor vehicle accident, collision with another vehicle	21,549
-	-	All listed conditions	5,195,711

SOURCE: Pitts, AM. Some notes on U.S. multiple cause of death data. Unpublished manuscript prepared under contract HRA 230-76-0202, October 1976.

APPENDIX Q. *Occurrence of diabetes on death certificates filed in South Carolina, 1979, by underlying cause of death*

Underlying Cause of Death	Number Listing Diabetes	Percent of All Certificates Listing Diabetes
Diabetes	32	33
Neoplasms	9	9
Nervous system disorders	1	1
Hypertensive heart disease	5	5
Acute myocardial infarction	21	22
Other ischemic heart diseases	10	10
Cerebrovascular diseases	8	8
Other heart and circulatory diseases	5	5
Influenza and pneumonia	2	2
Other respiratory diseases	2	2
Digestive disorders	1	1
Total	96	100

SOURCE: Diabetes Control Program, State of South Carolina, based on a random 1 in 14 sample of death certificates.

APPENDIX R. *Co-occurrence of diabetes and other conditions on death certificates in Louisiana, 1978*

Condition Listed on the Death Certificate	Number	Percent Which Listed Diabetes
Diabetes	3,052	100.0
Essential hypertension	131	83.2
Acute myocardial infarction	5,476	8.0
Chronic ischemic heart disease	6,000	10.1
Symptomatic heart disease	1,433	17.4
Cardiovascular diseases	2,453	10.1
Arteriosclerosis	783	21.2
Gangrene	95	41.1
Renal disease	248	25.4
All certificates	37,009	8.25*

*4.58 percent listed diabetes as the underlying cause of death; 3.67 percent listed diabetes as a contributing cause of death.

SOURCE: Diabetes Control Program, Louisiana Department of Health.

APPENDIX S. *Percent distribution of causes of death among diabetic Rochester, Minnesota, residents who died in 1965-74*

Underlying Cause of Death	Diabetes Mentioned on the Death Certificate	Diabetes Not Mentioned on the Death Certificate
Coronary heart disease	35.6	41.1
Arteriosclerosis	9.8	4.2
Stroke	2.5	4.5
Diabetes	24.5	0.0
Malignancy	5.5	18.9
Pneumonia	3.1	4.5
Liver disease	1.2	3.0
Renal disease	2.5	1.1
Chronic obstructive pulmonary disease (COPD)	0.6	2.3
Rheumatic heart disease	1.2	1.1
Pulmonary embolism	1.2	0.8
Other	12.3	18.5

SOURCE: Melton, LJ, and PJ Palumbo. Unpublished data.

APPENDIX T. *Occurrence of diabetes on all death certificates filed in Maine, 1976-1977, by underlying cause of death*

Underlying Cause of Death	Number Listing Diabetes	Percent of All Certificates Listing Diabetes
Diabetes mellitus	311	20.1
Malignant neoplasms	139	9.0
Diseases of the heart	737	47.7
Hypertension	5	0.3
Cerebrovascular diseases	157	10.2
Diseases of arteries, arterioles, and capillaries	42	2.7
(Arteriosclerosis)	(20)	(1.3)
Diseases of veins and lymphatics, and others of circulatory system	12	0.8
(Venous thrombosis and embolism)	(12)	(0.8)
Diseases of respiratory system	67	4.3
Cirrhosis of liver	13	0.8
Diseases of genitourinary system	13	0.8
(Nephritis and nephrosis)	(4)	(0.2)
(Infections of kidney)	(1)	(0.0)
All other causes	49	3.2
Total certificates listing diabetes	1,545	100.0

*In 1976-77, 20,305 death certificates were filed in Maine; 7.6 percent of these listed diabetes, and 1.5 percent listed diabetes as the underlying cause of death.

SOURCE: Bureau of Research and Vital Records, Department of Human Services, Augusta, Maine.

APPENDIX U. *Average length of life, United States, 1900-1980*

Year	Men	Women
1980	70.0	77.5
1970	67.1	74.7
1960	66.6	73.1
1950	65.6	71.1
1940	60.8	65.2
1930	58.1	61.6
1920	53.6	54.6
1910	48.4	51.8
1900	46.3	48.3

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

APPENDIX V. *Joslin Clinic, Boston, Massachusetts, patients with diabetes: remaining years of life at selected ages, 1947-51*

	Remaining Life Years (Expected)	
Attained Age (Years)	Patients with Diabetes*	U.S. White Population, 1949-1951
10	44.3	61.5
15	40.0	56.7
20	36.1	51.9
25	32.8	47.2
30	30.1	42.5
35	27.2	37.9
40	23.7	33.3
45	20.2	28.9
50	16.9	24.7
55	13.8	20.8
60	11.3	17.2
65	9.2	13.9
70	7.2	10.9

*Experience of 1947 to 1951 for diabetic patients first observed in 1930 to 1951. Excludes deaths within 1 week of first observation or hospital discharge.

SOURCE: Marks, HH. NY State J Med 61:602, 1961.

APPENDIX W. *Average annual death rates per 100,000 population from diabetes in various countries, by sex, 1977-78, and percent change, 1967-78 to 1977-78*

				Male			Female		
Country	Age-Adjusted* 1977-78	Death rate/ 100,000 (Crude) 1977-78	% Change 1967-68 to 1977-78	Age-Adjusted* 1977-78	Crude 1977-78	1967-68 to 1977-78	Age-Adjusted* 1977-78	Crude 1977-78	1967-68 to 1977-78
Americas									
United States	10.4	15.4	-16.8	10.5	13.1	-16.0	10.3	17.6	-17.4
Canada	9.5	12.7	-6.6	10.0	11.4	-5.0	9.1	14.0	-7.9
Chile[a]	14.2	10.7	35.4	14.8	9.9	35.6	13.7	11.5	35.3
Africa									
Egypt[b]	11.0	6.8	11.5	11.4	6.9	11.3	10.6	6.7	11.7
Asia									
Israel	7.9	8.4	64.7	7.1	7.3	62.2	8.6	9.5	66.7
Japan	7.1	8.5	37.1	7.8	8.2	34.4	6.5	8.7	38.1
Philippines[c]	5.0	2.7	28.6	4.8	2.7	28.6	5.3	2.8	33.3
Europe									
Austria	8.8	17.5	-15.9	8.2	12.2	-15.9	8.9	22.2	-15.9
Denmark	6.2	10.9	-16.2	6.5	9.5	-16.7	6.0	12.4	-14.5
England & Wales[a]	5.4	10.2	12.1	5.8	8.5	24.6	5.1	11.7	3.5
France[c]	9.4	16.7	-4.0	9.2	13.2	-0.8	9.4	20.1	-5.2
Germany, Fed. Rep.[d]	13.6	27.3	19.2	13.2	19.8	20.7	13.7	34.2	18.8
Greece	18.1	31.7	64.2	16.4	25.6	64.1	19.5	37.5	63.8
Hungary	9.0	15.3	57.7	7.1	10.1	71.2	10.3	20.2	53.0
Netherlands	6.9	11.0	-38.2	6.0	7.9	-31.9	7.6	14.1	-41.0
Northern Ireland[a]	3.5	5.5	-37.5	3.6	4.4	-29.0	3.5	6.5	-42.0
Norway	4.5	8.7	24.3	4.9	7.6	20.6	4.1	9.9	30.3
Scotland	7.3	12.4	-5.3	7.4	10.2	12.1	7.2	14.4	-13.8
Sweden	7.6	16.1	-13.4	8.3	14.5	-9.9	6.8	17.8	-15.6
Switzerland	9.9	19.0	-8.7	9.5	14.5	-7.1	9.9	23.1	-10.1
Yugoslavia[a]	7.5	8.7	40.3	6.6	6.7	36.7	8.1	10.8	45.9

*Adjusted on basis of age distribution of the United States total population, 1940

[a] 1976 and 1977

[b] 1974 and 1975

[c] 1975 and 1976

[d] Includes West Berlin

[e] 1970 and 1971

SOURCE: Computed by the Statistical Bureau of the Metropolitan Life Insurance Company, based on data from the Division of Vital Statistics, National Center for Health Statistics, Statistics Canada, and World Health Statistics Annual.

CHAPTER XXX. MORTALITY IN INSULIN-DEPENDENT DIABETES

Janice S. Dorman, Ph.D., and Ronald E. LaPorte, Ph.D.

SUMMARY

The mortality rate for insulin-dependent diabetes mellitus (IDDM) with onset at ages less than 17 years is about 3 per 1,000 diabetics per year at ages below 25 years and about 20/1,000/year at ages 25 and older. White males and females experience similar overall mortality rates, which are 5 and 11 times greater than the rates for nondiabetics of the same age. Black IDDMs have mortality rates that are about twice those of white IDDMs. About 12 percent of IDDMs die within 20 years after the onset of diabetes. The primary cause of death below age 20 is acute diabetic complications, but at older ages renal disease accounts for nearly half of deaths.

STUDIES OF IDDM MORTALITY

There is a paucity of data concerning the current mortality of individuals with IDDM (formerly juvenile-onset diabetes). The early studies were hampered by lack of separation of IDDM and noninsulin-dependent diabetes mellitus (NIDDM), and differentiations were made according to age at onset. The studies that have addressed mortality associated with IDDM have been cohort studies, in which a population of cases having IDDM or youth-onset diabetes was followed over time. These cohorts have come from three sources: life insurance enrollees (Goodkin 1975); patients in major diabetes centers such as the Joslin Clinic (Entmacher et al. 1964, Christlieb et al. 1981), Children's Hospital of Pittsburgh (Dorman et al. 1984), or Steno Memorial Hospital in Denmark (Deckert et al. 1978); and a population-based study of IDDM patients in Erie County, New York (Sultz et al. 1972). Population-based research is essential for an understanding of the true mortality risk of IDDM cases. For example, life insurance enrollees often are healthier than the general population, and children seen at diabetes centers may not be representative of all diabetic children because of potential differences in referral patterns. Population-based studies present a much less biased approach for examining the descriptive epidemiology of IDDM mortality and for investigating risk factors for mortality. There is very little of this type of research, however, and when IDDM mortality rates are described, it is important to know if the

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studies are not population-based, as the latter may limit the generalizability of their findings.

The two primary sources of data on IDDM mortality in the United States are the Joslin Clinic and the Children's Hospital of Pittsburgh. Both of these major centers have completed extensive followup studies. Neither is population-based, although at both centers attempts have been made to define the population. The Joslin Clinic restricted its study to children identified within 1 year of diagnosis, who were residents of Massachusetts, and were insulin-dependent at time of diagnosis. The data from Children's Hospital of Pittsburgh, located in Allegheny County, Pennsylvania, consist of the followup of 2,000 children seen within 1 year of diagnosis, under age 17 at diagnosis of diabetes, and using insulin at the time of hospital discharge. Because there is a population-based registry in Allegheny County, it is possible to compare the cases seen in Children's Hospital with cases from the total Allegheny County population. Over 60 percent of IDDM cases in the complete population were seen at Children's Hospital, and comparison of the characteristics at onset of diabetes has revealed similar patterns. As with the data from the Joslin Clinic, it is not certain that mortality of the identified cases truly reflect the long-term mortality experience of the IDDM population. However, it is of particular interest that the mortality results from these two centers are remarkably consistent with the only population-based study that has been completed (Sultz et al. 1972). Therefore, although neither cohort is population-based, the results appear to reflect the general mortality of persons with IDDM.

TIME TRENDS IN MORTALITY FROM IDDM

IDDM is one of the few chronic diseases for which a new mode of treatment has brought substantial reduction in mortality in a very short period of time. Before development of insulin in the 1920s, individuals diagnosed as having IDDM had an extremely poor prognosis; most patients died within 2 years of onset. After introduction of insulin, there was a rapid increase in life expectancy. Joslin Clinic data document this remarkable pheonomenon (Table 1). As a result of insulin therapy, there was an immediate reduction in mortality in the youngest age group from 386/1,000 to 61/1,000 per year. This rate was further reduced and in the 1950s was only 1/1,000. Therefore, over a period of just 40 years, there was more than a 350-fold reduction in mortality of young children with diabetes. Clearly, this represents one of the major accomplishments of modern medicine. Despite this dramatic reduction, however, IDDM is still associated with substantially elevated mortality.

AGE-SPECIFIC MORTALITY

Age-specific mortality rates have been determined for IDDM patients seen at Children's Hospital of Pittsburgh (Table 2). Rates were determined by dividing the number of deaths for each age group by the person-years of diabetes within the age group. For example, an individual who developed diabetes at age 12 and died at age 20 contributed 8 person-years of diabetes. The absolute risk of dying after age 20 for persons with IDDM was over 2 percent per year. Thus, each year after age 20, diabetics had 1 chance in 50 of dying. These results are quite similar to those seen at the Joslin Clinic and the Steno Memorial Hospital. The overall mortality rates for white male and female IDDMs seen at Children's Hospital were similar (6.4/1,000 for males and 5.8/1,000 for females) but were much higher than for the general population (Table 5). Little is known about mortality at older ages or about mortality of older-onset IDDMs.

TABLE 1. *Death rate per 1,000 diabetic patients* at specified ages, Joslin Clinic, Boston, Massachusetts, 1897-1961*

Age at Death (Years)	Naunyn Era	Allen Era	Insulin Era				
	1897-1914	1914-1922	1922-1926	1926-1929	1929-1938	1939-1947	1950-1961
10	824.0	386.1	61.4	19.1	8.1	3.3	1.0
20	614.0	410.8	89.4	18.3	12.6	7.9	3.4
30	359.8	236.8	74.8	33.4	13.9	11.3	14.4
40	165.7	115.1	34.7	23.8	16.6	13.6	15.3

*Excludes deaths within 1 week of first observation or hospital discharge.

SOURCE: Marks, HH. Longevity and mortality of diabetics. Am J Public Health 55:416-23, 1965.

TABLE 2. *Age-specific IDDM mortality rates for white males and females per 1,000 person-years of observation (PYO) at Children's Hospital of Pittsburgh, 1950-1981*

Age at Death (Years)	White Males		White Females	
	Observed Deaths/PYO	Mortality Rate Per 1,000 PYO	Observed Deaths/PYO	Mortality Rate Per 1,000 PYO
1-4	1/424	2.4	6/315	19.0
5-9	5/1,694	3.0	7/1,502	4.7
10-14	4/3,003	1.3	7/2,927	2.4
15-19	8/3,115	2.6	4/2,793	1.4
20-24	15/2,191	6.8	10/1,986	5.0
25-29	21/1,320	15.9	24/1,192	20.1
30-34	18/608	29.6	8/550	14.6
35+	8/185	43.2	0/192	-
Total	80/12,540	6.4	66/11,457	5.8

SOURCE: Dorman, JS, RE LaPorte, LH Kuller, K Cruickshanks, TJ Orchard, D Wagener, D Becker, D Cavander, and A Drash. The Pittsburgh insulin-dependent diabetes mellitus (IDDM) morbidity and mortality study: Mortality results. Diabetes 33:271-76, 1984.

SURVIVAL RATE BY DURATION OF IDDM

Table 3 presents the mortality experience by duration of diabetes for the Joslin Clinic, Children's Hospital of Pittsburgh, and Erie County, New York. The data are not directly comparable because the Joslin Clinic data excluded deaths occuring at onset of IDDM, whereas these were included in the data from Children's Hospital of Pittsburgh and the New York study. Further, the ages at onset were slightly different among the three studies. The Joslin Clinic included all IDDMs with onset under age 21 years; Children's Hospital included patients with onset under age 17 years, and Erie County included IDDMs with onset under age 15 years. Despite these differences, the results were quite consistent. Overall, 2 to 3 percent of the youth-onset/insulin-dependent diabetic patients died within the first 10 years of diabetes, and 12 to 13 percent died within the first 20 years of diabetes.

TABLE 3. *Percent survival of IDDM patients by duration of diabetes*

Duration of Diabetes (Years)	Dates of Study: Age at Onset of IDDM: Location:	1939–1964 <21 Years Joslin Clinic,* Boston (a)		1950–1981 <17 Years Children's Hospital of Pittsburgh (b)		1946–1961 <15 Years Erie County, New York (c)
	Sex:	Males	Females	Males	Females	Both Sexes
5		99.6	96.9	99.1	97.7	99.2
10		97.7	95.5	97.8	96.7	98.0
15		97.4	95.4	95.3	95.6	
20		88.9	87.4	88.1	88.5	
25		82.6	83.2			

*Excludes mortality occurring at onset of IDDM.

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c. Sultz, HA, ER Schlesinger, WE Mosher, and JG Feldman. Childbood diabetes mellitus. In: Long-term Childhood Illness. Pittsburgh: University of Pittsburgh Press, 1972.

RACE DIFFERENCES IN IDDM MORTALITY

Little is known concerning race differences in mortality among IDDM patients. There have been only two studies, with relatively small sample sizes, that examined mortality of black and white individuals with IDDM. The Erie County, New York study identified only one death among the 13 black IDDM patients. Although the results indicate that the risk was much higher for blacks compared to whites, the sample size was much too small to make meaningful conclusions. In the study from Children's Hospital of Pittsburgh, there were 11 deaths among the 88 blacks with IDDM, and the mortality rate for black IDDM patients was about twice that for whites (Table 4). The risk for black diabetics of dying in comparison to the black general population was higher than the risk for white diabetics compared to the white general population. Therefore, it is likely that this was a true racial difference, rather than a difference resulting from the known excess mortality in the black population. The results suggest that IDDM may have a stronger impact on blacks than on whites.

EXCESS MORTALITY AMONG IDDM PATIENTS

Of critical importance is the relative mortality of persons with IDDM compared to nondiabetics. This represents the degree to which IDDMs have excess mortality compared to the general population. To examine the relative mortality of IDDMs, the mortality rates for over 1,800 IDDMs seen at Children's Hospital since 1950 were compared to those for the general population through calculation of standardized mortality ratios (SMR), which are the number of deaths observed in the diabetics divided by the number expected in the general population of the same age multiplied by 100. A ratio of 100 would mean that the diabetics had the same mortality experience as the general population. A ratio of 125 would indicate a 25 percent increase in mortality. Table 5 presents the relative mortality experience for white diabetic males and females. As shown by the overall SMRs, the males were 5.4 times more likely to die than the general United States population of males, and females were 11.5 times more likely to die. Of critical importance was that, for both males and females, the risk markedly accelerated after age 25 and was approximately 20 times that seen in the general population.

EARLY MORTALITY

Of primary importance is early mortality associated with diabetes. Table 5 presents the excess mortality risk for diabetics under age 20 in the Children's Hospital of Pittsburgh population. The data are analyzed two ways, one with early mortality included (mortality within 6 months after diagnosis) and the other with early mortality excluded.

TABLE 4. *Comparison of black and white IDDM mortality rates among diabetics at Children's Hospital of Pittsburgh, 1951-80*

Age at Death (Years)	Rate Per 1,000 Diabetics		Ratio
	Blacks	Whites	Blacks/Whites
1-9	13.8	4.8	2.9
10-19	4.0	1.9	2.0
20-29	18.7	10.5	1.8
30+	46.2	22.1	2.1
Total	11.4	6.1	1.9
Age-adjusted rate*	12.3	6.1	2.0

*Age-adjusted by the direct method to the total diabetic population

SOURCE: Dorman, JS, RE LaPorte, LH Kuller, et al. The Pittsburgh insulin-dependent diabetes mellitus (IDDM) morbidity and mortality study: Mortality results. Diabetes 33:271-76, 1984

TABLE 5. *Excess mortality among IDDM patients seen at Children's Hospital of Pittsburgh, 1950-81, compared to nondiabetic persons*

Age at Death (Years)	Overall Standardized Mortality Ratio*		Standardized Mortality Ratio Excluding Early Deaths	
	White Females	White Males	White Females	White Males
1-4	2,606	261	869	-
5-9	1,437	633	411	253
10-14	882	283	378	141
15-19	270	182	270	182
20-24	823	363		
25-29	3,055	947		
30-34	1,699	1,728		
35+	--	2,057		
Total	1,153	540		

*An SMR of 500, for example, indicates that the diabetic rate is 5 times the nondiabetic rate.

SOURCE: Dorman, JS, RE LaPorte, LH Kuller, et al. The Pittsburgh insulin-dependent diabetes mellitus (IDDM) morbidity and mortality study: Mortality results. Diabetes 33:271-76, 1984.

The mortality ratios compared to the general population in both analyses were highly elevated. However, the critical mortality period was during the first 6 months after clinical onset of diabetes. Once a child developed IDDM and survived for at least 6 months, the immediate risk of dying was markedly reduced. After 6 months of diabetes, the mortality risk, although elevated, was not significantly higher than that of the general population. Thus, the critical mortality risk period for a diabetic under age 20 was within 6 months after diagnosis. After this period, the child's risk of dying was not significantly different from that of nondiabetics.

CAUSES OF DEATH

The causes of death for IDDM patients seen at the Children's Hospital of Pittsburgh (Table 6, Figure 1) were consistent with those reported from the Joslin Clinic. The primary cause of mortality among IDDMs ages 0 to 9 years was acute complications of diabetes, including ketoacidosis and coma. After age 20, however, renal disease became the major cause of death. Among patients 30 years of age and older, cardiovascular disease was a significant cause of death. Table 7 presents the SMRs for the various causes of death for males and females. Renal and cardiovascular disease mortality were extraordinarily high when compared to the general population, being about 56 and 13 times higher than expected.

TABLE 6. *Percent distribution of causes of death among 164 IDDM patients who died among 1,894 IDDMs diagnosed at age 0-17 years, Pittsburgh, 1950-81*

	Age at Death (Years)			
Cause of Death	0-9 (N=19)	10-19 (N=24)	20-29 (N=77)	30+ (N=37)
Not IDDM-related	25.0	31.9	17.1	13.5
Acute complications	75.0	50.0	2.6	-
Other IDDM complications	-	9.1	18.4	15.8
Renal disease	-	4.5	55.3	47.4
Heart disease	-	4.5	6.6	23.7

SOURCE: Dorman, JS, RE LaPorte, LH Kuller, et al. The Pittsburgh IDDM morbidity and mortality study. Diabetes 33:271-76, 1984.

As indicated in Figure 1, mortality under age 20 was primarly due to acute diabetes-related events, which are largely preventable. The number of deaths under age 25 years in the United States in which diabetes was recorded on death certificates as the underlying cause of death is presented in Table 8. The 190 deaths presumably occurred among insulin-dependent diabetics and potentially could have been prevented. In an additional 130 deaths under age 25, diabetes was recorded as a contributing cause of death.

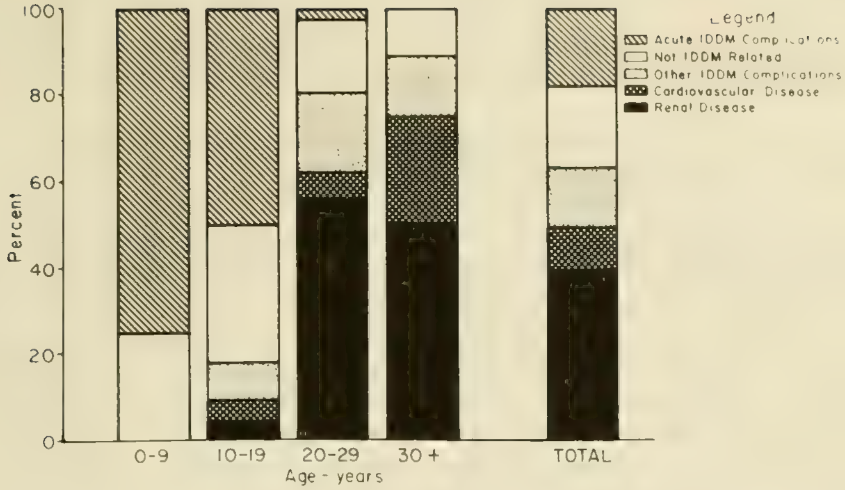

FIGURE 1. *Distribution of causes of death by age at death for IDDM patients seen at Children's Hospital of Pittsburgh, 1950-81*

SOURCE: Dorman, JS, RE LaPorte, LH Kuller, et al. The Pittsburgh insulin-dependent diabetes mellitus (IDDM) morbidity and mortality study: Mortality results. Diabetes 33:271-76, 1984.

TABLE 7. *Standardized mortality ratios (SMR)* by cause of death for IDDM patients with onset at age <17 years seen at Children's Hospital of Pittsburgh, 1950-81*

	White Males		White Females	
Cause of Death	Number of Deaths**	SMR	Number of Deaths**	SMR
All causes	80	540	66	1,153
All malignant neoplasms	1	85	2	236
Cardiovascular disease	8	1,137	7	1,591
Renal disease	34	55,618	24	56,163
Accidents and suicide	6	57	4	146

*An SMR of 500, for example, indicates that the diabetic rate is 5 times the nondiabetic rate.

**For white males, 54 deaths (68%) occurred under age 30; for white females, 58 deaths (88%) occurred under age 30.

SOURCE: Dorman, JS, RE LaPorte, LH Kuller, et al. The Pittsburgh insulin-dependent diabetes mellitus (IDDM) morbidity and mortality study: Mortality results. Diabetes 33:271-76, 1984.

TABLE 8. *Number of deaths under age 25 years with underlying cause of death attributed to diabetes mellitus, United States, 1982*

Age at Death (Years)	<1	1-4	5-14	15-24	0-24
Number of Deaths	8	9	33	140	190

SOURCE: Division of Vital Statistics, National Center for Health Statistics.

COMPARISON OF IDDM AND NIDDM MORTALITY

There are only limited data that contrast the mortality experiences of patients with IDDM and with NIDDM. However, it is possible to compare mortality of patients with youth-onset diabetes and older-onset diabetes, and, typically, individuals with youth-onset diabetes have a substantially poorer prognosis. Among insurance applicants there was more than an 11-fold excess mortality for individuals whose diabetes developed under age 15 compared to mortality in the general population (Table 9). In comparison, later-onset diabetes (after age 40) was associated with approximately a 2- to 3-fold excess mortality. These risks can be translated into life expectancy. At age 15, an individual with youth-onset diabetes in 1970 was likely to live only to age 47, whereas an individual who developed diabetes between age 40 and 49 was expected to live to the age of 69 years. The data indicate that youth-onset diabetes has a substantially greater impact on mortality than older-onset diabetes does.

TABLE 9. *Excess mortality rate among diabetic insurance applicants versus general population, 1951-70, and expectation of life*

Age (Years) at Onset of Diabetes	Ratio, Diabetic Mortality Rate Versus General Population Rate*	Expectation of Life (Years)	
		Diabetics	General Population
Under 15	11.27	32	59
15-19	9.26	33	56
20-29	4.43	33	49
30-39	3.44	28	39
40-49	3.01	20	30
50-59	2.13	17	23
60-70	2.34	11	16

*Expected deaths in general population based on Equitable's mortality tables 1958-1963.

SOURCE: Goodkin, G. Mortality factors in diabetes. J Occup Med 17:716-21, 1975.

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APPENDIX A. *Distribution of causes of death among deaths in diabetics under age 45, Washington State, 1968-79*

	Age at Death (Years)					
	0-24		25-34		35-44	
Cause of Death	Number	Percent	Number	Percent	Number	Percent
DKA, DA	40	50.6	24	13.6	31	9.2
Infection	12	15.2	14	8.0	18	5.3
Hypoglycemia	5	6.3	5	2.8	15	4.5
Heart disease	2	2.5	27	15.3	131	38.9
Renal disease	8	10.1	78	44.3	64	19.0
Cerebrovascular accident	0	-	10	5.7	23	6.8
"DM only"	7	8.9	11	6.3	11	3.3
"Non DM-related"	5	6.3	7	4.0	44	13.1
Total	79	100.0	176	100.0	337	100.0

SOURCE: Connell, F. Washington State Diabetes Control Program.

CHAPTER XXXI. HEALTH INSURANCE AND HEALTH CARE COVERAGE OF ADULT DIABETICS

Thomas F. Drury, Ph.D., Laura E. Montgomery,
and Bruce B. Cohen, Ph.D.

SUMMARY

About 90 percent of adult diabetics, and virtually every diabetic 65 years or older, have at least one form of health care coverage. Their pattern of coverage is similar to that of the general population of adults 20 years of age and over. About 7 of 10 diabetics have some form of private health insurance coverage, compared to about 8 of 10 persons in the general population. About two-fifths of adult diabetics have some Medicare coverage, but more than 9 of 10 aged 65 years and over have such coverage. One of nine have some type of coverage under military or Veterans Administration (VA) health benefits, and approximately the same proportion are estimated to have Medicaid coverage.

DATA SOURCES

The data analyzed in this chapter were obtained from the 1978 National Health Interview Survey (NHIS) of the National Center for Health Statistics (Givens 1979). The NHIS is a household interview survey of a stratified random sample of the civilian noninstitutionalized population of the United States. Survey respondents identified diabetic household members through responses to questions on hospitalizations, doctor visits, or disability days, indicating that they were due to diabetes, or by directly indicating that a household member had diabetes. Respondents were also queried about health insurance coverage and health care benefits obtained through the Social Security system, Medicare, Medicaid, and assistance through the Aid to Families with Dependent Children program; through insurance plans that cover hospital bills or doctor/surgeon bills; through health care provided or paid for by the VA, or by imputation, having a military-service connected disability; and by imputing health care coverage under the military system through having a spouse serving in the Armed Services (HISD 1981).

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TYPES OF HEALTH CARE COVERAGE OF DIABETICS

In 1978, 91.7 percent of adult diabetics had at least some form of health care coverage, whether in the form of private health insurance, Medicare, military or Veterans Administration health benefits, or Medicaid (Table 1).

TABLE 1. *Percent of the general population (GP) and of diabetics 20 years and over with selected types of health care coverage, United States, 1978*

	Age (Years)					
	20+		20-64		65+	
Type of Health Care Coverage	GP	Diabetic	GP	Diabetic	GP	Diabetic
Private health insurance or Medicare	85.5	85.1	83.1	77.3	97.8	98.1
Private health insurance	79.4	70.8	81.7	71.7	67.3	69.4
Medicare	16.6	41.4	2.0	8.7	94.1	95.9
Military or Veterans Administration health benefits	6.9	11.4	5.7	11.0	13.1	11.9
Medicaid	4.8	11.0	4.1	10.6	8.8	11.6
One or more of the above types	90.0	91.7	88.3	87.1	98.8	99.4

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from data of the 1978 National Health Interview Survey provided by the Division of Health Interview Statistics, National Center for Health Statistics.

Private Health Insurance Coverage

To be "covered by private health insurance" in the 1978 NHIS meant that a person was included under one or more private health insurance plans that paid any part of a hospital bill, or a doctor's or surgeon's bill (for operations). Some of these plans, particularly prepaid plans such as health maintenance organizations, surely covered ambulatory health care as well. But since specific questions about ambulatory coverage were not asked in the 1978 NHIS, it is not possible to estimate how many persons had such coverage as part of their private health insurance plan. A person could have had private health insurance coverage by virtue of being the main policyholder or by being a family member covered by the plan. In 1978, 70.8 percent of adult diabetics had some private health insurance coverage, based on these definitions (Table 1).

Medicare

Medicare is a public program that provides coverage of certain types of health care benefits for persons 65 years and over and for disabled persons under 65 years of age. In the 1978 NHIS, household respondents were asked to identify which household members had Medicare coverage. Based on their responses, it is estimated that about two of five (41.4 percent) adult diabetics had Medicare coverage in 1978 (Table 1).

Military and VA Health Care Coverage

As with other veterans, diabetic veterans have priority eligibility to receive health care services through the Veterans Administration (VA) if they have a service-connected disability, are receiving a pension from the VA, or are a veteran 65 years of age or over. Diabetics may also be eligible to receive health care benefits from the military services because they are civilian dependents of active military personnel, are military pensioners, or are civilian dependents of military pensioners. In the 1978 NHIS, individuals meeting these VA or military service eligibility criteria were approximated (NCHS 1981), and 11.4 percent of diabetics 20 years of age and over were estimated to have had some form of health care coverage through the VA or the military services (Table 1).

Medicaid Coverage

Medicaid is a public assistance program that provides health care services, but it is difficult to estimate how many persons are covered by this program. First, Medicaid is a State-operated program and the criteria of eligibility vary from State to State. Second, many persons only realize they are eligible for Medicaid assistance after they have received health care services. Third, individuals may become eligible for Medicaid only when the financial burden of care for illness is high, causing them to drain their resources and meet maximum income limits for eligibility. In the 1978 NHIS, individuals were identified as having Medicaid coverage if they had a valid Medicaid card, were recipients of Aid to Families with Dependent Children or Supplemental Security Income payments, or indicated that Medicaid coverage was the reason for not having any health insurance plan. Using these definitions, about 11.0 percent of adult diabetics 20 years of age and over had Medicaid coverage in 1978 (Table 1).

DIABETIC STATUS AND TYPES OF HEALTH CARE COVERAGE

Compared to the general population 20 years of age and over, diabetics were less likely to have private health insurance coverage but were more likely to have coverage under Medicare, Medicaid, and military or VA health benefits (Table 1). These overall differences primarily reflect differences by age group. For example, about 7 of 10 diabetics 20 years of age and over had some form of private health insurance, compared to about 8 of 10 persons in the general population. This difference occurred in the 20-64 age group, but among the elderly there was no difference in private health insurance coverage. The relative likelihood of having one or more types of coverage increased with age for both diabetics and the general adult population.

The estimates of private health insurance coverage may be biased upward for both diabetics and nondiabetics; because Medicare charges are handled locally by intermediary insurance companies, such as Blue Cross/Blue Shield, Medicare recipients who receive copies of paid invoices for their personal medical records from intermediary insurance companies may misinterpret these to mean that they have private health insurance when they actually do not (Ries 1984). This source of bias is taken into account in estimates of persons who have either private health insurance or Medicare, and from these combined data it appears that virtually all elderly persons, and about 80 percent of those ages 20-64 years, have at least one of these types of health care coverage whether or not they are diabetic (Table 1).

Persons under age 65 may receive health services under Medicare if they are disabled. Presumably, the 4.3-fold higher rate of Medicare coverage for diabetics ages

20-64 reflects a higher rate of Medicare-certified disability among diabetics versus the general population (Table 1).

Diabetics' participation in the Medicaid program was relatively higher than it was generally, but this difference also reflected higher levels of participation among diabetics 20-64 years of age (Table 1). Among persons 20-44 years of age, diabetics were about four times more likely than their similarly aged counterparts in the general population to have Medicaid coverage (16 percent versus 4 percent) (Appendix D). An estimated 11 percent of adult diabetics were identified in the 1978 NHIS as having either military or VA health benefits coverage, compared to 7 percent of the general population. Most of this difference reflects the greater percentage of diabetics 45-64 years of age having military or VA health care coverage (14 percent versus 9 percent, Table 1). Since diabetes with onset early in life is usually disqualifying for military service, the fact that diabetics have military health care coverage suggests that their disease started during or after military service.

The vast majority of diabetics have at least one or more of the above types of health care coverage. About 92 percent age 20 years and over were identified in 1978 as having either private health insurance, Medicare, Medicaid, or military or VA health benefits coverage (Table 1). Young diabetics were least likely (85 percent) to have any of these types of health care coverage, while virtually all (99.4 percent) elderly diabetics had some form of coverage. Within specific age categories the relative likelihood of diabetics having any identified coverage was similar to that of the general population.

SOCIODEMOGRAPHIC VARIATIONS IN HEALTH CARE COVERAGE AMONG DIABETICS

Table 2 summarizes the major variations in health care coverage that occur among categories of diabetics defined in terms of selected sociodemographic characteristics (see also Appendices A-E). Men, whites, and persons with 12 or more years of formal schooling were proportionately more likely to have private health insurance or military/VA health benefits coverage, but were less likely to have Medicare or Medicaid coverage. Age was a factor in the higher proportion with Medicare, Medicaid, and military/VA health benefits coverage; in Medicare, since it is a program for the elderly; in Medicaid, by virtue of economic need among younger diabetics; and in military/VA health benefits coverage, by experience, since diabetics in their middle and later years are more likely to be veterans than younger persons. Persons living in the South were less likely to have private health insurance coverage, but more likely to have Medicare, Medicaid, or military/VA health benefits coverage. Other variations highlighted in Table 2 are less consistent in specific details across types of coverage.

Descriptions of the extent of health care coverage among diabetics provide a rough indication of the kinds of resources that are available to persons with diabetes to cope with the financial burden of their disease. However, they tell us little, if anything, about the quality of that coverage. Diabetics also vary a great deal with respect to the burden of their illness. It is quite possible that diabetics who most need some form of health care coverage are the least likely to have that coverage.

TABLE 2. *Sociodemographic variations in health care coverage, United States, 1978**

Type of Health Care Coverage	Among Diabetics Age 20 Years and Over, Coverage is Relatively	
	More Likely For:	Less Likely For:
Private health insurance	Men Whites Persons with 12+ years of education Persons in families with $10,000+ annual income in 1978 Persons living in the North Central region	Women Races other than white Persons with <12 years of education Persons in families with <$10,000 annual income in 1978 Persons living in central cities Persons living in the South
Medicare	Persons age 65+ years Women Races other than white Persons with <12 years of education Persons in families with <$10,000 annual income in 1978 Persons living outside SMSAs Persons living in the Northeast and South	Persons age <65 years Men Whites Persons with 12+ years of education Persons in families with $10,000+ annual income in 1978 Persons living within SMSAs Persons living in the North Central and West
Military or VA health benefits coverage	Persons age 45+ years Men Whites Persons with 12+ years of education Persons in families with annual incomes between $7,000 and $24,999 in 1978 Persons living in central cities and in farm areas outside SMSAs Persons living in the South and West	Persons age <45 years Women Races other than white Persons with <12 years of education Persons living in families with <$7,000 or $25,000+ annual income in 1978 Persons living outside central cities in SMSAs, or in nonfarm areas outside SMSAs Persons living in the Northeast and North Central regions
Medicaid	Persons ages 20-44 years Women Races other than white Persons with <12 years of education Persons in families with <$7,000 annual income in 1978 Persons living in central cities Persons living in the South and West	Persons age 45+ years Men Whites Persons with 12+ years of education Persons in families with $15,000+ annual income in 1978 Persons living outside central cities within SMSAs Persons living in the Northeast and North Central regions
One or more of the above types of coverage	Older persons Whites Persons with some college or more education Persons living in the North Central region	Younger persons Races other than white Persons with <12 years of education Persons living in the West

*See Appendices A-E for more detail.

FAMILY INCOME AND TYPES OF HEALTH CARE COVERAGE

Economic needs were assessed in terms of being in a family with an annual income under $7,000 (economically "needy"), roughly the bottom fifth of the general population annual family income distribution in 1978. Among diabetics, as among the population generally, those who were economically needy were less likely to have had private health insurance coverage and more likely to have had Medicare and Medicaid coverage than those who were not needy (Table 3). The percent of diabetics with any type of health care coverage was quite similar among those in families in the lowest fifth and the upper four-fifths of the income distribution (Table 3). The family income differentials in specific types of coverage primarily reflected the coverages of

TABLE 3. *Percent of persons age 20 years and over with selected types of health care coverage, by annual family income, diabetic status, and age, United States, 1978*

Type of Health Care Coverage and Age	General Population		Diabetics	
	<$7,000	≥$7,000	<$7,000	≥$7,000
Age 20+ years				
Private health insurance or Medicare	70.0	90.4	77.3	89.9
Private health insurance	53.3	87.8	59.1	79.2
Medicare	38.9	9.6	55.1	31.5
Military or VA health benefits	6.9	6.7	7.3	12.4
Medicaid	17.5	1.3	22.1	4.2
One or more of the above types of coverage	82.1	92.9	89.1	93.0
Age 20-64 years				
Private health insurance or Medicare	53.9	89.5	55.1	86.3
Private health insurance	49.4	88.9	45.5	82.4
Medicare	6.0	1.1	13.5	6.9
Military or VA health benefits	5.2	5.8	8.6	11.8
Medicaid	19.1	1.2	30.1	3.9
One or more of the above types of coverage	72.4	92.2	79.4	90.4
Age 65+ years				
Private health insurance or Medicare	97.5	98.8	98.5	99.2
Private health insurance	59.9	77.4	72.2	70.6
Medicare	95.6	93.2	95.0	97.4
Military or VA health benefits	9.8	15.9	6.0	13.8
Medicaid	14.9	2.8	14.4	5.0
One or more of the above types of coverage	98.7	99.5	98.5	100.0

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from data of the 1978 National Health Interview Survey provided by the Division of Health Interview Statistics, National Center for Health Statistics.

diabetics 20-64 years of age. By contrast, family income similarities in having any health care coverage primarily reflected similarities in any coverage among elderly diabetics. Among diabetics 20-64 years of age, only 45.5 percent in lower income families had private health insurance, while 82.4 percent in higher income families had such insurance; lower family income was also associated with a greater likelihood of having Medicare and Medicaid coverage. In the 20-64 year age group, while 90.4 percent of all higher income diabetics had some type of coverage, only 79.4 percent in lower income families did. Thus about 21 percent of young and middle-aged diabetics in families with less than $7,000 annual income did not have any of the four types of health care coverage measured in the 1978 NHIS (Table 3). Two income differences in patterns of coverage among elderly diabetics deserve comment: (1) elderly diabetics in higher income families were more likely to have military or VA health benefits coverage; and (2) elderly diabetics in lower income families were more likely to have Medicaid coverage (Table 3). These family income differentials mostly followed general population patterns.

HEALTH STATUS AND TYPES OF COVERAGE

General health status was assessed in the 1978 NHIS in terms of responses to a single question on perceived health status—"Compared to other persons your age, would you say that your health is excellent, good, fair, or poor?" Diabetics in poor or fair health were less likely than those in excellent or good health to have had private health insurance (Table 4). Among diabetics 20-64 years of age, those in fair or poor health were more likely to have had Medicare, Medicaid, or military/VA health benefits coverage than those in excellent or good health. Virtually every elderly diabetic in fair or poor health had some type of coverage because of the Medicare and Medicaid programs. However, a substantial proportion (17 percent) of young and middle-aged diabetics in fair or poor health did not have any major source of coverage. The patterns of health insurance coverage for diabetics mostly followed general population trends, although the general population of adults 20-64 years of age in fair or poor health were more likely than diabetics to have had private health insurance.

HEALTH STATUS AND TYPES OF COVERAGE AMONG LOWER INCOME FAMILIES

Among diabetics living in lower income families, those in fair or poor health were less likely than those in excellent or good health to have private health insurance, about equally likely to have Medicare coverage, and less likely to have one or more of four types of health care coverage in 1978 (Table 4). These differentials primarily reflected differences among diabetics 20-64 years of age and largely followed general population trends. Among persons in lower income families who were 20-64 years of age but in excellent or good health, diabetics were more likely to have had private health insurance than the general population and to have had one or more of the four types of health care coverage.

TABLE 4. *Percent of persons age 20 years and older with selected types of health care coverage, by family income and self-assessed health status, United States, 1978*

Type of Health Care Coverage and Age	Income <$7,000 in 1978				All Income Levels			
	General Population		Diabetics		General Population		Diabetics	
	Fair/ Poor	Excellent/ Good	Fair/ Poor	Excellent/ Good	Fair/ Poor	Excellent/ Good	Fair/ Poor	Excellent/ Good
Age 20+ years								
Private health insurance or Medicare	68.4	70.7	70.2	88.3	78.9	86.8	79.1	91.2
Private health insurance	44.6	57.1	49.8	73.5	64.4	82.4	61.2	81.1
Medicare	49.4	34.2	53.8	56.2	35.0	13.0	44.2	37.8
Military or VA health benefits	9.3	5.8	8.4	5.5	10.8	6.1	12.4	9.9
Medicaid	24.9	14.2	27.0	13.5	12.1	3.4	16.9	4.8
One or more of the above types of coverage	84.1	81.2	85.9	94.2	87.7	90.5	89.3	94.0
Age 20-64 years								
Private health insurance or Medicare	47.1	56.6	45.2	76.4	71.2	85.1	68.3	86.9
Private health insurance	36.1	54.6	32.6	73.8	65.7	84.3	59.9	84.2
Medicare	15.4	2.3	18.5	2.6	9.7	0.7	15.2	1.8
Military or VA health benefits	7.9	4.0	10.2	5.2	9.7	5.0	13.6	7.7
Medicaid	29.4	15.0	37.3	14.3	11.8	2.8	17.1	3.6
One or more of the above types of coverage	73.2	72.1	74.2	90.7	83.1	89.2	83.3	91.1
Age 65+ years								
Private health insurance or Medicare	97.4	97.6	100.0	96.6	96.8	98.2	98.2	97.9
Private health insurance	56.6	61.9	70.5	73.3	61.1	70.1	63.5	76.1
Medicare	95.5	95.6	96.3	93.3	94.1	94.2	95.7	95.8
Military or VA health benefits	11.1	9.2	6.3	5.8	13.3	13.0	10.1	13.4
Medicaid	18.8	12.6	14.5	13.0	12.6	7.0	16.4	6.7
One or more of the above types of coverage	98.9	98.7	100.0	96.6	98.5	99.1	100.0	98.7

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from data of the 1978 National Health Interview Survey provided by the Division of Health Interview Statistics, National Center for Health Statistics.

PATTERNS OF AMBULATORY HEALTH CARE AND TYPES OF COVERAGE

The vast majority of diabetics not only have a well-defined point of entry into the health care system, but routinely visit a private doctor's office or doctor's clinic. A substantial minority also use a hospital outpatient clinic or emergency room as their usual place of care. Not surprisingly, these patterns of ambulatory care were associated with the extent of health care coverage a person had. Diabetics who routinely visited a private doctor's office or doctor's clinic were more likely to have had some type of coverage and to have had some form of private health insurance or Medicare than diabetics who usually received medical care services at a hospital outpatient clinic or emergency room (Table 5). The latter, by contrast, were much more likely to have had Medicaid coverage.

TABLE 5. *Percent of persons in the general population (GP) and with diabetes (DM), age 20 years and over with selected types of health care coverage, by regular source of care and usual place of care, United States, 1978*

	Has Regular Source of Care						No Regular Source of Care	
	All Places		Doctor's Office		Outpatient Clinic			
Type of Health Care Coverage	GP	DM	GP	DM	GP	DM	GP	DM
Private health insurance or Medicare	86.8	85.2	89.8	89.6	59.0	49.6	79.1	84.2
Private health insurance	80.7	70.9	83.9	75.6	50.9	33.9	73.7	70.6
Medicare	17.7	42.2	18.4	44.5	14.0	25.7	11.4	27.4
Military or VA health benefits	7.0	10.9	5.2	8.9	23.8	20.2	5.9	16.6
Medicaid	5.1	11.3	4.1	8.9	13.9	31.6	3.4	6.6
One or more of the above types of coverage	91.6	92.0	92.4	93.2	84.7	81.1	83.0	85.9

SOURCE: Computed by the Division of Epidemiology and Health Promotion, from data of the 1978 National Health Interview Survey provided by the Division of Health Interview Statistics, National Center for Health Statistics.

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APPENDIX A. *Percent of persons age 20 years and over with private health insurance, United States, 1978*

	Age (Years)							
	20+		20-44		45-64		65+	
Characteristic	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics
All persons age 20 years and over	79.4	70.8	80.6	68.2	83.7	72.9	67.3	69.4
Sex								
Men	80.8	75.4	82.0	69.8	84.5	80.2	68.2	71.2
Women	78.1	67.7	79.2	66.9	82.9	67.3	66.6	68.5
Race								
White	81.4	74.7	82.4	71.5	85.8	77.4	70.1	72.8
All other races	64.1	49.0	68.5	46.7	65.7	48.6	39.7	50.5
Black	62.4	48.9	66.8	46.7	64.1	49.3	39.5	49.1
Education (years)								
<12	65.6	60.3	61.7	33.2	73.3	60.7	60.8	65.2
12	84.2	81.8	82.5	78.7	89.2	82.7	78.3	81.9
13 or more	88.3	85.4	88.1	85.7	91.5	89.9	80.9	79.5
Family income								
<$7,000	53.3	59.1	47.9	31.7	51.9	50.4	59.9	72.2
$7,000 - $9,999	71.3	62.3	67.8	38.6	74.4	53.8	75.6	73.2
$10,000 - $14,999	84.3	77.0	83.5	74.0	88.1	84.6	79.2	65.2
$15,000 - $24,999	92.2	87.6	92.1	91.3	95.0	92.7	77.7	69.5
$25,000 or more	93.5	87.9	93.9	90.6	95.2	88.3	77.5	80.1
Location of residence								
Within SMSA	80.6	71.4	81.5	70.4	85.0	74.7	68.2	67.1
Central city	75.8	65.7	76.6	57.1	80.8	70.1	64.0	63.4
Outside central city	84.2	77.0	84.9	80.6	88.1	79.0	72.0	71.4
Outside SMSA	76.6	69.6	78.3	62.2	80.7	67.9	65.8	73.2
Nonfarm	76.6	69.6	78.8	62.0	80.3	69.2	65.4	72.3
Farm	76.5	69.6	72.9	63.8	83.9	56.2	69.3	79.5
Geographic region								
Northeast	81.2	73.0	81.2	65.6	88.8	83.2	67.2	65.9
North Central	85.3	80.5	86.8	79.7	88.0	81.0	74.6	80.3
South	75.2	65.3	77.5	58.6	78.1	67.1	62.7	65.7
West	75.5	63.4	75.8	71.3	80.1	59.0	65.1	66.8

SOURCE: Division of Epidemiology and Health Promotion, from 1978 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX B. *Percent of persons age 20 years and over with Medicare coverage, United States, 1978*

	Age (Years)							
	20+		20-44		45-64		65+	
Characteristic	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics
All persons age 20 years and over	16.6	41.4	0.6	4.5	4.3	10.2	94.1	95.9
Sex								
Men	15.0	37.9	0.8	4.8	4.8	10.7	93.5	97.3
Women	18.1	43.8	0.5	4.2	3.8	9.9	94.6	95.1
Race								
White	17.0	40.9	0.6	4.1	4.0	8.9	94.7	96.3
All other races	13.6	44.2	0.9	6.7	6.6	17.2	88.9	93.2
Black	14.4	44.0	0.9	6.7	6.4	17.5	89.1	93.0
Education (years)								
<12	32.6	53.2	2.0	12.8	7.6	14.9	94.1	95.7
12	9.7	24.7	0.3	0.0	2.8	6.3	94.1	96.2
13 or more	8.9	32.1	0.3	2.0	1.6	5.0	94.7	97.1
Family income								
<$7,000	38.9	55.1	2.6	11.6	11.7	14.2	95.6	95.0
$7,000 - $9,999	23.7	57.6	0.9	0.0	8.2	21.0	96.2	97.9
$10,000 - $14,999	12.1	33.0	0.5	3.6	3.4	9.7	92.5	97.3
$15,000 - $24,999	5.9	24.0	0.1	0.0	2.2	8.5	92.8	95.6
$25,000 or more	5.2	11.9	0.1	0.0	1.0	0.0	88.9	100.0
Location of residence								
Within SMSA	15.1	36.5	0.6	4.2	3.8	7.6	94.2	95.7
Central city	17.1	39.5	0.8	7.1	4.7	8.9	93.2	93.9
Outside central city	13.5	33.5	0.4	1.9	3.2	6.5	95.0	97.9
Outside SMSA	20.1	52.3	0.8	5.3	5.3	17.3	94.1	96.1
Nonfarm	20.1	52.0	0.8	5.9	5.7	18.0	94.2	96.4
Farm	20.3	54.2	0.9	0.0	2.7	10.7	93.6	93.8
Geographic region								
Northeast	17.6	42.3	0.7	9.1	3.6	1.2	94.8	95.4
North Central	15.5	38.9	0.3	0.0	3.4	9.4	94.6	96.1
South	17.7	44.9	0.9	4.8	5.5	16.0	93.2	96.7
West	15.3	35.2	0.7	5.1	4.4	10.4	94.4	93.9

SOURCE: Division of Epidemiology and Health Promotion, from 1978 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX C. *Percent of persons age 20 years and over with military or Veterans Administration health benefits coverage, United States, 1978*

	Age (Years)							
	20+		20-44		45-64		65+	
Characteristic	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics
All persons age 20 years and over	6.9	11.4	3.7	3.5	9.2	13.7	13.1	11.9
Sex								
Men	10.2	22.1	3.7	7.7	14.4	24.1	26.2	27.1
Women	3.9	4.0	3.6	0.0	4.4	5.7	3.9	3.5
Race								
White	7.0	12.1	3.8	4.1	9.2	14.0	13.5	13.5
All other races	5.6	6.8	3.0	0.0	9.5	12.1	9.2	2.5
Black	5.5	6.9	2.5	0.0	9.4	12.3	9.8	2.6
Education (years)								
<12	7.1	9.0	2.5	0.0	8.0	12.2	10.8	7.9
12	6.9	11.5	4.6	5.5	9.5	12.7	12.3	13.6
13 or more	6.5	15.5	3.2	2.2	10.9	22.1	19.6	21.9
Family income								
<$7,000	6.9	7.3	3.4	3.6	8.3	10.4	9.8	6.0
$7,000 - $9,999	7.1	11.9	5.0	0.0	8.0	17.9	11.1	8.5
$10,000 - $14,999	7.0	10.8	4.1	6.0	10.0	15.7	14.8	5.7
$15,000 - $24,999	6.5	16.1	3.7	5.5	9.8	15.9	19.9	30.3
$25,000 or more	6.5	8.8	3.2	0.0	9.2	10.2	22.5	21.3
Location of residence								
Within SMSA	6.8	11.8	3.5	1.5	9.3	14.7	13.8	13.1
Central city	6.3	15.0	2.9	3.5	8.8	18.4	12.8	15.5
Outside central city	7.1	8.7	4.0	0.0	9.6	11.2	14.7	10.3
Outside SMSA	7.1	10.3	4.0	9.5	9.1	11.0	11.9	10.0
Nonfarm	7.3	9.9	4.1	10.5	9.7	11.2	12.0	8.5
Farm	5.5	13.6	2.9	0.0	5.2	8.4	11.0	19.9
Geographic region								
Northeast	5.7	9.0	2.3	2.9	7.4	10.3	12.5	10.1
North Central	5.1	9.0	2.4	3.8	7.0	10.9	11.3	9.4
South	8.5	13.2	5.0	5.3	11.8	17.2	13.6	11.1
West	8.2	15.2	5.0	0.0	10.5	14.7	15.8	24.6

SOURCE: Division of Epidemiology and Health Promotion, from 1978 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX D. *Percent of persons age 20 years and over with Medicaid coverage, United States, 1978*

	Age (Years)							
	20+		20-44		45-64		65+	
Characteristic	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics
All persons age 20 years and over	4.8	11.0	4.5	15.5	3.3	8.9	8.8	11.6
Sex								
Men	2.7	6.9	1.9	10.9	2.1	4.6	7.5	8.3
Women	6.7	13.8	7.0	19.3	4.4	12.2	9.7	13.4
Race								
White	3.5	8.2	3.2	10.8	2.4	6.5	6.6	9.1
All other races	14.9	27.0	13.7	47.0	10.5	21.9	30.0	26.0
Black	15.9	27.4	14.7	47.0	11.4	22.2	30.7	26.7
Education (years)								
<12	11.2	16.4	14.4	30.9	6.8	15.7	12.9	14.2
12	2.5	4.8	3.2	13.1	1.2	1.8	3.0	5.7
13 or more	1.2	4.2	1.2	5.9	1.2	4.3	1.4	2.1
Family income								
<$7,000	17.5	22.1	21.1	47.5	15.6	24.0	14.9	14.4
$7,000 - $9,999	4.1	9.8	4.8	25.5	4.3	16.0	2.6	2.0
$10,000 - $14,999	1.9	5.1	1.8	6.8	1.1	2.2	3.9	9.3
$15,000 - $24,999	0.6	1.4	0.6	0.0	0.4	0.0	2.4	6.9
$25,000 or more	0.4	1.0	0.3	0.0	0.3	1.6	1.8	0.0
Location of residence								
Within SMSA	4.6	10.3	4.8	14.2	3.3	8.7	7.0	10.5
Central city	7.7	14.7	8.1	27.8	5.4	11.3	10.6	13.8
Outside central city	2.4	5.9	2.5	3.7	1.7	6.3	3.6	6.5
Outside SMSA	5.3	12.6	4.0	19.3	3.3	9.4	11.8	13.4
Nonfarm	5.7	12.8	4.2	17.5	3.7	9.3	12.9	14.5
Farm	1.8	11.3	2.1	36.2	0.9	10.7	2.7	6.2
Geographic region								
Northeast	5.4	9.9	6.8	21.9	3.0	5.5	5.6	9.5
North Central	3.4	9.6	3.1	11.9	2.5	10.8	6.0	7.0
South	5.4	11.7	3.9	18.1	3.7	6.9	13.3	15.3
West	5.3	13.5	5.0	5.6	4.0	15.2	8.7	14.9

SOURCE: Division of Epidemiology and Health Promotion, from 1978 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

APPENDIX E. *Percent of persons age 20 years and over with one or more types of coverage,* United States, 1978*

	Age (Years)							
	20+		20-44		45-64		65+	
Characteristic	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics	U.S.	Diabetics
All persons age 20 years and over	90.0	91.7	86.7	84.5	91.0	88.0	98.8	99.4
Sex								
Men	89.5	93.2	85.4	84.0	92.3	92.1	99.2	100.0
Women	90.4	90.7	88.0	84.9	89.9	84.9	98.6	99.0
Race								
White	90.7	92.8	87.3	84.0	92.0	90.1	99.0	100.0
All other races	84.9	85.5	83.2	88.1	83.2	76.9	97.0	95.7
Black	84.2	86.0	82.1	88.1	82.6	78.0	96.8	95.6
Education (years)								
<12	86.6	89.2	76.8	66.5	84.9	83.3	98.7	99.0
12	90.9	92.3	87.9	89.5	94.1	90.3	99.1	100.0
13 or more	92.9	98.0	90.9	93.8	96.3	100.0	99.4	100.0
Family income								
<$7,000	82.1	89.1	70.4	79.3	75.8	79.4	98.7	98.5
$7,000 - $9,999	83.6	91.4	76.6	64.2	83.7	86.3	99.6	100.0
$10,000 - $14,999	90.7	90.8	87.8	80.6	93.4	90.0	99.4	100.0
$15,000 - $24,999	95.5	96.5	93.9	94.3	98.0	96.3	99.7	100.0
$25,000 or more	96.1	92.3	95.0	90.6	97.3	91.5	99.3	100.0
Location of residence								
Within SMSA	90.7	91.5	87.7	83.6	92.3	89.2	98.7	98.9
Central city	89.3	92.0	85.6	84.9	90.8	89.7	98.2	98.0
Outside central city	91.8	91.0	89.2	82.5	93.4	88.8	99.2	100.0
Outside SMSA	88.4	92.1	84.5	87.2	88.2	84.7	99.0	100.0
Nonfarm	88.7	92.6	85.1	85.9	88.5	86.5	99.1	100.0
Farm	85.4	88.6	77.5	100.0	86.5	66.9	98.7	100.0
Geographic region								
Northeast	91.7	92.8	88.1	84.6	93.7	91.1	98.7	97.7
North Central	92.8	96.1	90.6	91.6	93.7	94.9	99.2	100.0
South	87.7	89.4	84.3	79.2	87.7	84.2	98.7	100.0
West	87.5	87.3	83.5	81.9	89.4	81.7	98.8	100.0

*Includes private health insurance, Medicare, military or Veterans Administration health benefits coverage, and Medicaid.

SOURCE: Division of Epidemiology and Health Promotion, from 1978 National Health Interview Survey data provided by the Division of Health Interview Statistics, National Center for Health Statistics.

CHAPTER XXXII. ECONOMIC IMPACT OF DIABETES

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SUMMARY

Diabetes is a disease of major proportions in the United States. It continues to be ranked among the 10 leading causes of death; is a significant cause of hospitalizations, visits to physicians, and other direct medical services; it creates disability and absences from work, and impairs normal daily activities. Costs are incurred because of each of these factors, but, because diabetes is related to other acute and chronic conditions that are often considered the reason for the medical expense rather than diabetes, it is quite difficult to estimate its full impact. However, the lowest estimates indicate that the total economic impact of diabetes in the United States is at least $14 billion annually. Estimates of direct costs for medical care range from $7.4 billion to $12 billion. About half of the costs result from hospital care and one-fourth from nursing home care. The per capita cost for health care of diabetics is about two to three times that of nondiabetics.

CLASSICAL ESTIMATES OF THE COST OF ILLNESS

There are several classical methodologies and studies in estimating the economic impact of illness that provide an excellent framework for calculating single-year cost of illness, disability, and death (Mushkin and Collings 1959, Rice 1966, Hodgson 1983, Berk et al. 1978, Hodgson and Meiners 1982). Perhaps the most commonly used methodology is the "Human Capital Approach" of Rice (1966), which differentiates two categories of costs: direct medical care costs and indirect costs due to disability and premature death. Direct cost categories include expenditures for prevention, detection, treatment, rehabilitation, research, training, and capital investment in medical facilities, including both public and private expenditures. Specific categories are personal services and supplies, such as hospital care, nursing home care, physicians'

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services, dentists' services, other medical professional services, drugs and drug sundries, eyeglasses and appliances, school health services, industrial health services, and medical activities in Federal units other than hospitals. Nonpersonal services include medical research, construction, government public health activities, voluntary health agencies, and health insurance costs.

The indirect cost of an illness is a measure of potential productivity lost to society. Indirect cost categories include loss of output to the economy due to illness, disability, and premature death, calculated as wages lost resulting from days lost from work. One component is morbidity losses due to decreased productivity on the job, absenteeism, and unemployment. Total productivity is generally considered to be the market value of all goods and services produced, or the gross national product; wages have been used traditionally as a surrogate for productivity. A second component of indirect cost is the value of productivity not realized in a year due to disease-related deaths, as well as the present value of future productivity lost as a result of deaths in that year.

"HUMAN CAPITAL" ESTIMATES OF THE COST OF DIABETES

Using the methodology and procedures of the Human Capital Approach of Rice (1966), the cost of diabetes can be estimated. To calculate direct medical care costs for diabetes, total health care costs for each medical care category were ascertained from pertinent surveys of the National Center for Health Statistics. The proportion that could be attributed to diabetes was set equal to the proportion of each health care category for which diabetes was the primary diagnosis, e.g., diabetes as the primary diagnosis on a hospital discharge record. Thus, the costs of diabetes as secondary or lower diagnoses are not included, and the total direct medical care costs that might be attributed to diabetes are underestimated. Indirect costs of diabetes due to lost wages or earnings were determined from the number of beneficiaries receiving Social Security payments with diabetes as the primary reason for the disability and from Bureau of Labor Statistics data on average daily earnings. Indirect costs due to mortality were based on deaths where diabetes was the primary reason for the death (underlying cause) and the expected value of lifetime earnings of these individuals had they not died. Since only underlying-cause deaths were considered, whereas about three-fourths of diabetes deaths are coded to diabetes as a contributory cause of death, there is underestimation of the impact of diabetes in these indirect cost calculations.

The total estimated costs for diabetes using the Human Capital Approach have increased from almost $2.6 billion in 1969 to $13.75 billion in 1984 (Table 1). This increase is due, in large part, to inflation and the increasing number of diabetics. Total national health expenditures have increased from $65.6 billion in 1969 to an estimated $387 billion in 1984 and now account for 10.9 percent of the gross national product (HIAA 1983). Total expenditures for diabetes have increased proportionately to total health care expenditures, and, although diagnosed diabetes occurs in only about 2.5 percent of the population, it accounts for about 4.0 percent of national health care expenditures (Table 1). The proportion of total costs attributable to direct medical care expenditures has risen over this period from 38 percent to 54 percent (Table 1) as the prevalence of diabetes has risen. Disability costs have also increased. The number of deaths attributed to diabetes as the underlying cause of death, however, has not changed greatly during this period, even though the prevalence of diagnosed diabetes has increased, and hence the proportion of total cost due to premature mortality has declined.

TABLE 1. *Trends in the estimated cost and impact of diabetes using the Human Capital Approach, United States, 1969-84*

	1969	1973	1975	1977	1980	1984
Cost of diabetes ($ millions)[a]						
Direct cost of medical and health care services[b]	996	1,650	2,520	3,400	4,800	7,430
Indirect cost due to disability resulting in lost wages and earnings[c]	464	980	1,680	2,340	3,440	4,440
Indirect cost due to premature death resulting in lost wages and earnings[d]	1,129	1,385	1,070	1,040	1,460	1,880
Total cost	$2,589	$4,015	$5,270	$6,780	$9,700	$13,750
Distribution of costs (percent)						
Direct medical care	38	41	48	50	50	54
Indirect cost of disability	18	24	32	35	35	32
Indirect cost of mortality	44	35	20	15	15	14
Prevalence of diagnosed diabetes (millions)[e]	3.2	4.2	4.8	5.0	5.5	-
Total U.S. health care costs ($ billions)[f]	65.6	103.4	132.7	170.2	248.0	387.0
Percent attributable to diabetes	4.0	3.9	4.0	4.0	3.9	3.6

[a] 1984 data are estimated. Direct cost estimates were derived by using components of the Consumer Price Index and applying these inflation factors to corresponding 1980 cost items. Indirect costs were estimated by applying the relative increase of household earnings between 1980 and 1984 and using estimates for number of deaths due to diabetes.

[b] Includes costs of care in short-stay hospitals, physicians' services, drugs, nursing home care, and other medical professional services. Does not include medical costs incurred by diabetics for conditions other than diabetes.

[c] Includes the dollar equivalent of years lost from work and keeping house due to disability caused by diabetes. Does not include such losses due to other diseases in diabetics.

[d] Includes the dollar equivalent of years lost due to death from diabetes as the underlying cause of death. Does not include such losses due to diabetes as a contributing cause of death or deaths of diabetics in which diabetes was not listed on the death certificate.

[e] National Health Interview Survey, National Center for Health Statistics.

[f] Health Care Financing Administration, Department of Health and Human Services.

SOURCE: Entmacher, PS, Metropolitan Life Insurance Company, New York.

The separate direct medical care cost components for 1980 and 1984 are detailed in Table 2. Over a quarter of the expenses are for nursing home care, while about half of the costs result from hospital care. Patients' visits to physicians compose about one-sixth of the expenses.

TABLE 2. *Estimated direct costs* (millions of dollars) for certain medical care services for diabetes, United States, 1980 and 1984*

Medical Service	1980 $ Millions	1980 Percent	1984** $ Millions	1984** Percent
Care in short-stay hospitals	2,200	46	3,540	48
Patient visits to physicians	840	17	1,180	16
Drugs and medications	380	8	580	8
Nursing home care	1,240	26	1,950	26
Other medical professional services	140	3	180	2
Total	$4,800	100	$7,430	100

*Estimated using the Human Capital Approach methodology. Does not include costs incurred by diabetics for conditions other than diabetes.

**Derived by using components of the Consumer Price Index and applying these inflation factors to corresponding 1980 cost items.

SOURCE: Entmacher, PS, Metropolitan Life Insurance Company, New York.

The 1980 health care expenditures for diabetes have been calculated independently (Table 3). Direct expenditures for diabetes ($4.3 billion) were slightly less than those in Table 2, but the difference might have been reduced by as much as one-half if expenditures for outpatient hospital care had been included in the calculations in Table 3. Females with diabetes, who constituted 57 percent of the diabetic population, had greater total health care costs and costs in each individual category than males, who represented only 43 percent of diabetics.

The age groups are divided in Table 3 to identify persons who were eligible for Medicare. The costs for males under 65 years of age were greater than for ages 65 and over, except for nursing home care and other professional services. For females, the total costs were greater for those age 65 and over, as were costs for nursing home care and other professional services. Hospital care and drug expenses were greater for females under age 65, while costs for physicians' services were about the same. Per capita personal health care expenditures for diabetes more accurately represent expenditures by age and sex. Here again, expenditures for females were greater than for males, and this was true in each expense category. Expenses for nursing home care of the elderly were particularly greater for females than for males. Total per capita expenditures, and expenditures in each category, for persons 65 years of age and over were much greater than for those under age 65 for both sexes.

TABLE 3. *Estimated personal health care expenditures for diabetes as the primary reason for the expense, United States, 1980**

Sex and Age (Years)	Number of Diabetics** (Millions)	All Health Care	Hospital Care***	Physicians' Services	Other Professional Services	Nursing Home Care	Drugs
		Total Expenditures ($ Millions)					
Both sexes, all ages	5.4	$4,301	$1,822	$893	$47	$1,137	$402
Males							
All ages	2.4	1,511	681	361	13	300	156
<65	1.5	871	477	206	3	94	91
65+	0.8	640	204	155	10	206	65
Females							
All ages	3.1	2,788	1,140	531	34	837	246
<65	1.8	1,248	724	269	4	117	134
65+	1.3	1,539	416	262	29	720	112
		Average Per Person Expenditures ($)					
Both sexes, all ages		$18.56	$7.86	$3.85	$.20	$4.91	$1.74
Males							
All ages		13.53	6.10	3.23	.12	2.69	1.40
<65		8.62	4.72	2.04	.03	.93	.90
65+		59.95	19.11	14.52	.94	19.30	6.09
Females							
All ages		23.24	9.50	4.43	.28	6.98	2.05
<65		11.92	6.91	2.57	.04	1.12	1.28
65+		101.02	27.31	17.20	1.90	47.26	7.35

*Estimated using the Human Capital Approach methodology. Does not include costs incurred by diabetics for conditions other than diabetes.

**1979-81 National Health Interview Survey, National Center for Health Statistics.

***Excludes expenditures for outpatient hospital care.

SOURCE: Hodgson, T, National Center for Health Statistics. Computed by the Division of Analysis from data provided by the Health Care Financing Administration, National Center for Health Statistics, and other organizations.

COST ESTIMATES FROM POPULATION-BASED HEALTH SURVEYS

The classical cost estimate methodologies are generally based on aggregate data for broad categories of disease, usually by body system, and a dollar value is derived for specific diseases such as diabetes by knowing the proportion of diabetics in the population. The assumption is made that the proportion of the costs for diabetes will be the same as the proportion of persons with diabetes. There now are several more direct sources for data on costs of diabetes from population-based health surveys, but it is important to note that these surveys were carried out in different years using different techniques. While the results are not always consistent, the trends in costs and the relationships to the costs for the nondiabetic population are noteworthy.

In the National Health Interview Survey (NHIS), conducted by the National Center for Health Statistics, about 10,000 households in the United States were surveyed during the first 3 months of 1976, and about 500 persons identified themselves as having been diagnosed by a physician as being diabetic. Household members completed a questionnaire about their health care experiences and out-of-pocket medical expenses incurred during 1975. Costs covered by health insurance or other sources were not included in the survey. The 1977 National Medical Care Expenditure Survey (NMCES), conducted by the National Center for Health Services Research (NCHSR), was a study of approximately 14,000 randomly selected households in the United States in which six interviews were conducted during 1977-78. Information was obtained on the use of various types of health services and associated charges. This household component was supplemented by a survey of physicians and facilities that had provided medical care to persons in these households and a survey of employers and insurance companies responsible for the health insurance coverage of the households (NCHSR 1981). The 1980 National Medical Care Utilization and Expenditure Survey (NMCUES), conducted by the National Center for Health Statistics, consisted of a national household survey of about 6,600 families containing about 17,100 persons, of whom 411 were persons with diabetes. These families and persons were queried five times during 1980 about their health care experiences and expenses.

The NHIS data on per capita expense in 1975 in each of several medical care categories are shown in Table 4. The per capita expenses for medical care are out-of-pocket costs only and do not include costs covered by health insurance and other sources. In addition, they are the average only for persons who had some expense in the category and are not averaged over the whole population or over all diabetics. The percent of persons having an expense varied greatly by medical care category, age, and by whether or not the person was diabetic. In most categories in Table 4, per capita out-of-pocket expense for diabetics was greater than for the general population of the United States. This differential was highest among younger persons. The greatest difference between diabetics and all persons was in the prescribed medicine category, and diabetics who obtained prescribed medicines spent about 2.5 times more out-of-pocket than did the general population. For health insurance premiums, the largest expense category, the ratio was 1.7; for hospital care, the next largest category, it was about 1.3.

In the 1977 NMCES, 98.9 percent of diabetics but only 86.9 percent of nondiabetics had some direct medical care expense (Table 5). The percent with an expense varied widely by age and by medical care category, and in all categories except dental, a higher percent of diabetics than nondiabetics had an expense. This in itself accounted for higher total direct medical care costs for diabetes. In addition, however, the average per capita expense for each medical care service except dental was higher for diabetic users of the service than for nondiabetic users. For example, total per capita expense for diabetics with an expense was 2.7 times that of nondiabetics. This ratio declined with age and was only 1.5 times higher for diabetics age 65 years and over; ratios varied by age and medical care category.

TABLE 4. *Average out-of-pocket cost* per person having an expense in certain medical categories, ages 20 years and over, United States, 1975*

Age (Years) and Medical Category	Percent with Out-of-Pocket Expenses		Persons with Out-of-Pocket Expenses		
			Average Dollar Cost for:		
	General Population	Diabetics	General Population	Diabetics	Ratio, Diabetics to General Population
Ages 20+					
Vision	24	29	$ 69	$ 69	1.0
Dental	38	26	109	146	1.3
Hospital	11	19	299	400	1.3
Hospital premium	53	57	122	136	1.1
Physicians	54	61	128	211	1.6
Prescribed medicines	51	68	71	181	2.5
Health insurance	72	72	341	594	1.7
Ages 20-44					
Vision	18	14	$ 67	$ 54	0.8
Dental	40	33	95	143	1.5
Hospital	11	20	197	216	1.1
Hospital premium	45	43	92	124	1.3
Physicians	51	64	100	180	1.8
Prescribed medicines	47	66	45	158	3.5
Health insurance	70	67	250	464	1.9
Ages 45-64					
Vision	30	30	$ 72	$ 73	1.0
Dental	40	27	129	169	1.3
Hospital	11	18	330	403	1.2
Hospital premium	56	49	145	143	1.0
Physicians	55	60	146	199	1.4
Prescribed medicines	52	68	87	185	2.1
Health insurance	73	68	401	591	1.5
Ages 65+					
Vision	28	35	$ 65	$ 68	1.0
Dental	28	23	120	115	1.0
Hospital	14	20	505	481	1.0
Hospital premium	70	73	150	132	0.9
Physicians	59	62	177	239	1.4
Prescribed medicines	61	70	114	187	1.6
Health insurance	76	78	502	649	1.3

*Costs incurred by persons in nursing homes or covered by health insurance or other sources are not included. Expenses are not additive because the number of persons having an out-of-pocket expense in each medical care category varies.

SOURCE: Drury, T, from data of the 1976 National Health Interview Survey, National Center for Health Statistics.

TABLE 5. *Amount and percent of persons with expenditures for direct medical care, excluding nursing home care, United States, 1977*

	Diabetics			Nondiabetics		
Age (Years) and Medical Care Category	Total Expense ($ Millions)	Percent of All Diabetics	$ Per Person with Expense	Total Expense ($ Millions)	Percent of All Nondiabetics	$ Per Person with Expense
All ages	None	1.1	-	None	13.1	-
Total expenses	$6,939	98.9	$1,514	$98,747	86.9	$ 548
Vision	59	15.6	82	1,607	10.8	72
Dental	154	29.0	115	11,198	42.5	127
Hospital care	4,826	27.5	3,784	56,794	11.3	2,417
Hospital stay	3,610	27.5	2,831	41,835	11.3	1,783
Physicians	1,169	26.9	940	14,423	11.0	634
Other	47	4.5	222	536	1.2	214
Ambulatory care	1,224	95.4	277	23,350	76.2	148
Physician contacts	980	94.0	225	20,091	73.4	132
Nonphysician contacts	244	31.5	167	3,259	17.8	88
Prescribed medicines	577	94.6	132	5,000	58.4	41
Other medical expenses	98	17.2	125	799	6.3	62
Under age 45	None	1.3	-	None	13.8	-
Total expenses	$669	98.7	$ 965	$47,591	86.2	$ 379
Vision	9	12.7	101	817	8.3	67
Dental	27	41.8	93	7,754	43.5	122
Hospital care	455	24.8	2,617	23,317	9.5	1,691
Hospital stay	331	24.8	1,904	16,690	9.4	1,213
Physicians	117	24.2	685	6,473	9.1	488
Other	7	1.4	750	153	0.7	157
Ambulatory care	132	97.0	194	13,363	74.8	123
Physician contacts	119	97.0	180	11,674	72.0	111
Nonphysician contacts	13	28.8	65	1,689	15.8	74
Prescribed medicines	40	87.8	64	2,031	54.4	26
Other medical expenses	5	19.1	41	308	4.9	43
Ages 45-64	None	1.0	-	None	12.2	-
Total expenses	$2,545	99.0	$1,343	$28,471	87.8	$ 781
Vision	25	17.4	76	571	17.8	77
Dental	64	30.0	111	2,639	44.2	144
Hospital care	1,664	24.5	3,551	17,361	13.6	3,078
Hospital stay	1,281	24.5	2,733	12,696	13.6	2,251
Physicians	371	23.1	810	4,458	13.3	808
Other	12	3.1	205	207	1.6	318
Ambulatory care	499	94.4	276	6,000	77.9	186
Physician contacts	433	93.3	242	5,158	73.8	165
Nonphysician contacts	66	31.6	109	842	21.5	94
Prescribed medicines	255	95.6	139	1,684	64.8	63
Other medical expenses	38	13.9	145	217	7.6	68
Ages 65+	None	1.1	-	None	9.7	-
Total expenses	$3,725	98.9	$1,867	$22,685	90.3	$1,239
Vision	25	14.9	84	219	14.0	77
Dental	63	23.5	132	805	31.9	124
Hospital care	2,706	31.4	4,277	16,116	20.1	3,959
Hospital stay	1,998	31.4	3,158	12,448	20.1	3,061
Physicians	681	30.5	1,106	3,492	19.5	881
Other	27	7.0	192	176	4.3	200
Ambulatory care	593	95.8	307	3,987	82.6	238
Physician contacts	428	94.6	224	3,259	80.1	201
Nonphysician contacts	165	32.4	253	728	24.6	146
Prescribed medicines	283	96.0	146	1,285	74.6	85
Other medical expenses	54	19.3	140	274	13.4	101

SOURCE: Meyers, S, MI Harris, T Drury, and P Entmacher, from data of the 1977 United States National Medical Care Expenditure Survey, Household Data, National Center for Health Services Research.

The total direct medical care expense for diabetics in the 1977 NMCES survey was $6.9 billion, compared to $3.4 billion estimated in Table 1. It is likely that this difference resulted from the different methodologies used in ascertaining costs. In the NMCES, all costs for all persons identified as diabetic were ascertained, whereas the data in Table 1 were based only on medical care services where diabetes was considered to be the primary reason for the service. An estimate of costs attributable only to diabetes in NMCES can be obtained by subtracting the nondiabetic from the diabetic per capita costs. For example, for all ages the total expense per person attributable to diabetes would be $966 ($1,514 - $548), or $4.8 billion for the estimated 5 million diabetics in 1977.

The 1980 NMCUES survey, unlike the two surveys above, ascertained per capita expense averaged over all diabetics or over all nondiabetics regardless of whether all persons had medical expenses or not. This average per capita expense has also been calculated for the 1977 NMCES survey, and both sets of data are shown in Table 6. The expenses in 1980 are greater than those in 1977, which is to be expected because of inflation and the rising prevalence of diabetes. However, the ratios of diabetic costs to nondiabetic costs are identical and range from 1.7 times higher for diabetics age 65 years and older to 2.9 times higher for diabetics age less than 45 years. The ratios are similar by race even though expenditures of whites were substantially higher than those of nonwhites. Ratios and absolute expenditures were not direct functions of either family income or self-perceived health status (Table 6).

TABLE 6. *Average per-person health care expense, excluding nursing home expense, United States, 1977 and 1980*

	1980			1977		
Characteristics	Diabetics	Nondiabetics	Ratio	Diabetics	Nondiabetics	Ratio
Age (years)						
All ages	$2,078	$ 686	3.0	$1,498	$ 476	3.1
<45	1,411	492	2.9	953	327	2.9
45-64	1,657	913	1.8	1,330	686	1.9
65+	2,845	1,648	1.7	1,847	1,119	1.7
Race						
White	2,181	709	3.1			
Nonwhite	1,581	538	2.9			
Family income ($)						
<$12,000	2,321	920	2.5			
12,000-19,999	2,502	660	3.8			
20,000-24,999	1,529	541	2.8			
25,000 and over	1,433	662	2.2			
Self-perceived health status						
Excellent	2,001	421	4.8			
Good	1,291	744	1.7			
Fair	2,015	1,242	1.6			
Poor	3,636	2,642	1.4			

SOURCES: 1980 National Medical Care Utilization and Expenditure Survey, National Center for Health Statistics. 1977 National Medical Care Expenditure Survey, National Center for Health Services Research.

Data from NMCUES and NMCES (Table 7) show that persons with diabetes utilized health services more than persons without diabetes, which would have resulted in higher health care expenditures. The utilization rates were higher for every category except dental care. In both surveys, the difference in hospitalization rates was about 2.5 times greater, while the rates for all visits to doctors in NMCUES were 2.2 times greater for diabetics than for nondiabetics.

TABLE 7. *Health services utilization rates, excluding nursing home patients, United States, 1977 and 1980*

	Number of Visits Per Person, 1980			Percent of Persons with a Visit, 1977		
Health Service	Diabetics	Nondiabetics	Ratio	Diabetics	Nondiabetics	Ratio
Hospitalization	0.45	0.17	2.6	28	11	2.5
Dental	0.88	1.38	0.6	29	43	0.7
Vision	-	-	-	16	11	1.5
Emergency room	0.33	0.27	1.2	-	-	-
Doctor visits	6.04	2.71	2.2	94*	73*	1.3
Prescribed medicines	-	-	-	96	58	1.6
Other visits	1.70	1.03	1.7	-	-	-
Other expenses	-	-	-	17	6	2.7
Nights in hospital	5.16	1.17	4.4	-	-	-

*Contacts in ambulatory care setting only.

SOURCES: 1980 National Medical Care Utilization and Expenditure Survey, National Center for Health Statistics; 1977 National Medical Care Expenditure Survey, National Center for Health Services Research.

Table 8 shows that overall hospital costs, including inpatient hospital care and inpatient physician services, accounted for 70 percent of total direct health care expenditures for persons with diabetes, compared to about 58 percent for persons without diabetes. The percent accounted for by prescribed medications was also higher for diabetics, but visits to doctors, both inpatient and ambulatory, made up a greater percentage of expenditures for nondiabetics than for diabetics. This was also true for dental care and for ambulatory care from other health professionals.

TABLE 8. *Percent distribution of health care expenditures, excluding nursing home expenses, United States, 1977 and 1980*

	1980		1977	
Health Service	Diabetics	Nondiabetics	Diabetics	Nondiabetics
All hospital care	70.2	58.2	69.5	57.5
Inpatient hospital	61.5	48.8	-	-
Inpatient physician	8.7	9.4	-	-
Ambulatory physician	12.4	17.8	14.1	20.3
Ambulatory other health professional	4.3	5.8	3.5	3.3
Dental	2.3	11.5	2.2	11.3
Vision	-	-	0.8	1.6
Prescribed medicine	7.6	4.6	8.3	5.1
Other	3.3	2.2	1.4	0.8

SOURCES: 1980 National Medical Care Utilization and Expenditure Survey, National Center for Health Statistics. 1977 National Medical Care Expenditure Survey, National Center for Health Services Research.

SYNTHETIC ESTIMATES OF THE COST OF DIABETES

Data from the National Health Interview Survey indicate that there were about 16.9 million outpatient contacts with physicians for diagnosis and treatment of diabetes in 1980. The 1980 NAMCS estimates for visits to office-based physicians were similar, being 9.55 million visits for diabetes as the primary diagnosis and an additional 6.7 million visits for diabetes as a secondary diagnosis, for a total of 16.25 million visits. In the NMCUES, diabetics had an average of 6.04 visits to physicians per person in 1980, for a total of 33 million visits for the 5.5 million diabetics in the United States. Using these three estimates for number of physician visits, and the estimated average nonsurgical physician's fee of $31 (HIAA 1983), the total cost for outpatient contacts for diabetes ranged from $504 million to $1.03 billion.

Data from the 1980 National Hospital Discharge Survey provided estimates of an average length of hospital stay for diabetes of 10.5 days, 638,000 hospitalizations for diabetes as the primary diagnosis, and 1,633,000 hospitalizations for diabetes as a secondary diagnosis. In the 1980 NMCUES, diabetics had an average of 5.16 nights in the hospital per person in that year, for a total of 28.4 million hospital days for the 5.5 million diabetics. Using these two estimates for number of hospital days, and the estimated average cost of $245 per hospital day (HIAA 1983), the total cost for hospitalizations for diabetes ranged between $5.8 billion and $7.0 billion.

There are few data on the costs of specific complications of diabetes. In 1980 the number of lower extremity amputations was estimated at 40,381. With an average length of stay of approximately 30.5 days (Most and Sinnock 1984), there were about 1.2 million days in the hospital for these procedures. At an average cost of $245 per day (HIAA 1983), the total hospitalization cost for lower extremity amputation was about $302 million, which does not include rehabilitation, premature mortality, or disability costs.

In 1979 total Medicare reimbursement for end-stage renal disease due to diabetic nephropathy was estimated at $22,770 per person (Eggers 1984). Thus, for the nearly 5,300 persons with diabetic nephropathy enrolled in the Medicare End-Stage Renal Disease Program in 1979, total costs are estimated to have been $120.7 million.

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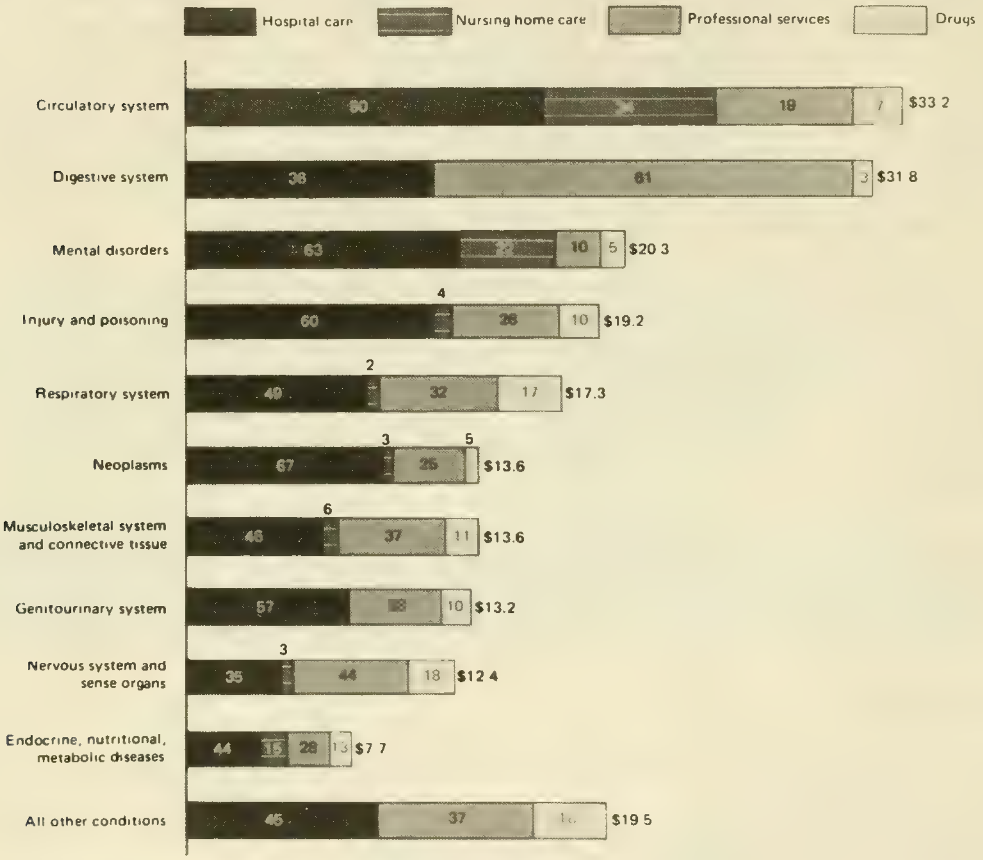
APPENDIX A. *Personal health care expenditures ($ billions) and percent distribution, by condition and type of care, United States, 1980*



SOURCE: Hodgson, TA, and AN Kopstein. Health care expenditures for major diseases. Health, United States, 1983. DHHS Pub. No. (PHS) 84-1232, December 1983.

APPENDIX B. *Family income of diabetics and the general population age 20 years and older, United States, 1979-81*

Sex and Family Income	20+ Years		20-44 Years		45-64 Years		65+Years	
	General Popula-tion	Diabetics	General Popula-tion	Diabetics	General Popula-tion	Diabetics	General Popula-tion	Diabetics
Both sexes				Number (thousands)				
	134,908	4,775	75,348	763	38,817	2,112	20,743	1,900
				Percent Distribution				
Under $3,000	4.0	6.7	3.6	6.0	3.0	5.8	7.4	8.1
$3,000-$4,999	6.2	13.1	4.0	5.8	4.4	9.1	17.2	20.5
$5,000-$6,999	7.2	11.4	5.3	8.0	5.8	9.2	16.5	15.2
$7,000-$9,999	9.2	12.1	7.6	7.7	8.0	10.8	16.9	15.2
$10,000-$14,999	16.4	16.8	16.8	12.3	15.2	18.9	17.1	16.4
$15,000-$24,999	26.0	18.9	29.7	28.7	25.7	21.5	13.3	12.1
$25,000 or more	31.2	20.9	33.0	31.4	38.1	24.8	11.6	12.4
Men				Number (thousands)				
	63,648	2,068	36,436	315	18,578	994	8,634	759
				Percent Distribution				
Under $3,000	2.9	3.7	3.1	4.3	2.1	4.2	4.1	2.8
$3,000-$4,999	4.6	8.7	3.4	2.4	3.1	5.7	12.8	15.3
$5,000-$6,999	6.3	9.0	4.8	6.2	4.5	5.4	16.1	14.7
$7,000-$9,999	8.5	10.6	7.2	6.9	6.4	7.4	18.8	16.3
$10,000-$14,999	16.2	17.9	16.4	11.0	14.0	17.1	20.0	21.7
$15,000-$24,999	27.6	23.4	30.8	32.6	27.1	27.5	15.1	14.1
$25,000 or more	33.9	26.8	34.3	36.6	2.8	32.7	13.1	15.2
Women				Number (thousands)				
	71,261	2,707	38,913	449	20,239	1,118	1,211	1,140
				Percent Distribution				
Under $3,000	4.9	9.0	4.0	7.2	3.8	7.1	9.7	11.6
$3,000-$4,999	7.6	16.5	4.7	8.2	5.7	12.2	20.3	24.0
$5,000-$6,999	8.0	13.3	5.8	9.3	6.9	12.7	16.9	15.5
$7,000-$9,999	9.7	13.2	8.1	8.3	9.4	13.8	15.6	14.5
$10,000-$14,999	16.5	16.1	17.1	13.2	16.2	20.4	15.0	12.9
$15,000-$24,999	24.6	15.5	28.7	26.0	24.4	16.1	12.0	10.8
$25,000 or more	28.7	16.4	31.8	27.8	33.7	17.7	10.5	10.6

SOURCE: Drury, T, from data of the 1979-81 National Health Interview Surveys, National Center for Health Statistics.

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